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ABSTRACT

This publication presents the results of a survey conducted to determine the viewpoint of industry regarding the subject matter that should be included in ocean engineering education programs. Questionnaires were mailed to over 1,000 individuals; 270 replies, or 27 percent of those surveyed, respond. Seventy percent of the replies indicated involvement in some aspect of ocean engineering. The results showed that many of the established disciplines are involved in ocean engineering activities. The principal courses recommended were basic sciences, core material, applied sciences and humanities for an undergraduate curriculum; basic materials and applications were considered most desirable for graduate studies. (Author/BT)

INDUSTRY'S INTEREST IN OCEAN ENGINEERING EDUCATION PROGRAMS

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ABSTRACT

A survey was conducted to determine the viewpoint of industry regarding the subject matter which should be included in an ocean engineering educational program.

Questionnaires were mailed to over 1000 individuals. 270 replies were received, or 27% of those questioned replied. Seventy percent of the replies received indicated involvement in some aspect of ocean engineering. The results of the study are summarized in graphical and tabular form.

The results showed that many of the established disciplines are involved in ocean engineering activities. Those working in the field often hold advanced degrees and were involved in more than one subfield. The majority of those questioned favored offering ocean engineering on both the undergraduate and graduate levels. For the B.S. curriculum, basic sciences, core material, applied sciences, and humanities were deemed desirable, while for the M.S. curriculum, basic materials and applications were considered most desirable.

PREFACE

A survey of the industrial viewpoint regarding the content of ocean engineering curriculum was made as part of the Coastal and Ocean Engineering educational program at Texas A&M University.

The report was principally written by the author with assistance from Miss Diana DeMott and Mr. David Stockard. The manuscript was typed by Mrs. Karen Weeks.

The study was partially supported by the National Oceanic and Atmospheric Administration's Sea Grant Program Institutional Grant GH-101 to Texas A&M University.

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INTRODUCTION

A great deal of interest, both public and private, has been shown in recent years in activities and development along the coast and offshore areas. A need for an ocean engineering curriculum was recognized by several educational institutions, and programs are now available in some twenty-one institutions, principally on the graduate level.(1)*

Since most of the programs were initiated by academicians, it was felt that advice and recommendations regarding such programs and regarding contents of such programs should be sought from Industry. A survey was conducted by Texas A&M University's Coastal and Ocean Engineering Division to get some idea of the industrial viewpoint.

This survey was conducted by mailing questionnaires to approximately one-thousand individuals working in industry and government. About 27 percent responded, of which 30 percent indicated that they were not involved in ocean engineering activities at this time.

1. Mail Survey

Mailing Procedures and Results:

Questionnaires were mailed to over 1,000 individuals. These individuals were selected in the belief that they had some connection with ocean engineering. However, in case they were not involved in an ocean engineering activity, they could so indicate on the questionnaire, and return it unanswered. The total number of questionnaires returned was approximately 270, or 27% or those mailed. Of these 270 questionnaires, approximately 90 (30% of those received) said they

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* Numbers in parentheses refer to references listed on page 69.

were not involved in ocean engineering activities, 180 said they were (7 of which were from the U.S. Army Corps of Engineers) involved.

The questionnaires returned were from thirty-three states, and from 23 foreign countries. Since the questionnaires were the sole basis for analysis, a further breakdown may be informative. In this group, 25 states and 17 foreign countries were represented. (Exact figures are given in Table I)

2. The Questionnaire

Completion of the questionnaires was designed to take less than 15 minutes. Basically, the questionnaire had two parts, "Background and Employment Profile" and "Training in Ocean Engineering". The training portion inquired about both the Undergraduate Curriculum and Master's Degree Program. The majority of questions asked were multiple choice and/or fill in blank. Space was also provided for any comments the individual might wish to make.

STATES	TOTAL NUMBER OF QUESTIONNAIRES RETURNED	QUESTIONNAIRES ANSWERED
Alaska	1	0
California	53	39
Colorado	4	4
Connecticut	1	1
Delaware	1	1
Florida	3	2
Hawaii	1	1
Illinois	6	4
Indiana	2	2
Kansas	1	0
Louisiana	7	6
Maryland	9	7
Massachusetts	4	2
Michigan	2	2
Mississippi	3	2
Missouri	2	1
Nebraska	1	0
New Jersey	3	4
New Mexico	1	0
New York	18	12
North Carolina	2	2
Ohio	2	1
Oklahoma	7	6
Oregon	4	1
Pennsylvania	19	6
South Carolina	2	2
Tennessee	2	1
Texas	56	42
Utah	1	0
Wisconsin	2	0
Washington	2	1
Washington, D.C.	5	3
Virginia	11	9
Government (Corps of Engineers)		7
COUNTRIES		
Australia	1	1
Canada	6	4

TABLE I

STATES AND COUNTRIES REPRESENTED BY SURVEY

COUNTRIES	TOTAL NUMBER OF QUESTIONNAIRES RETURNED	QUESTIONNAIRES ANSWERED
England	2	2
France	3	2
Germany	1	0
India	1	1
Ireland	1	1
Japan	4	3
Mexico	1	1
Netherlands	1	0
New Zealand	1	1
Portugal	1	1

TABLE I (CONT.)

STATES AND COUNTRIES REPRESENTED BY SURVEY

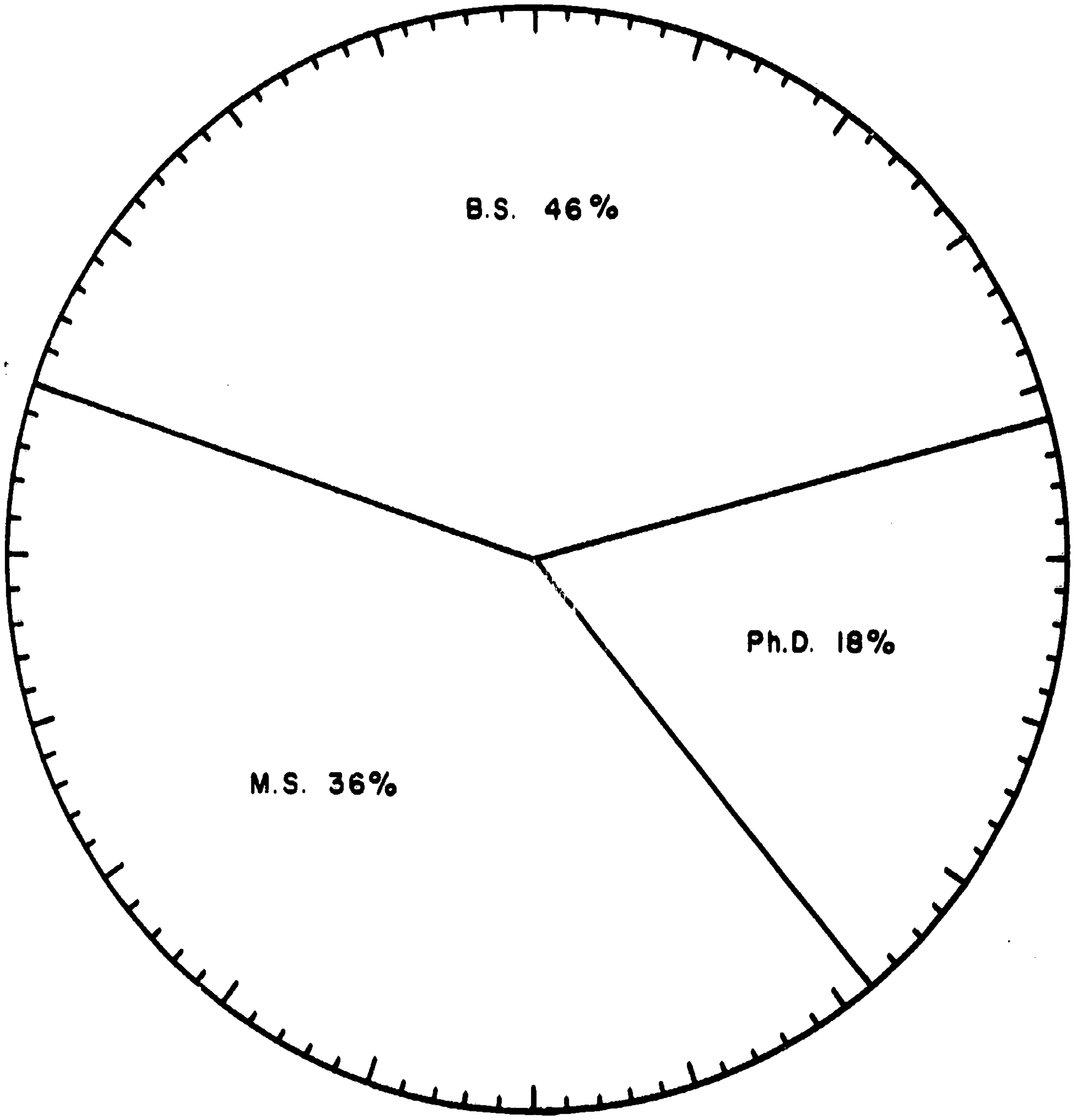
RESULTS OF THE SURVEY

PART I. Background and Employment Profile

The purpose of this section was to provide basic background information on the individual and his employment in industry. In this way, one could get an idea regarding the practice of Ocean Engineering in industry and government. The questions dealt with educational background, employment figures, and practical aspects of Ocean Engineering in industry and government. The section consisted of six questions.

QUESTION 1: *Highest Degree Attained*

Forty-six percent of the respondents held B.S. degrees, 36 percent held M.S. degrees, and 18 percent held Ph.D.'s The largest group held B.S. degrees, closely followed by M.S. degrees. It is interesting to note, that very few of the degrees had an ocean engineering designation, as shown in question 2.



QUESTION I. HIGHEST DEGREE ATTAINED

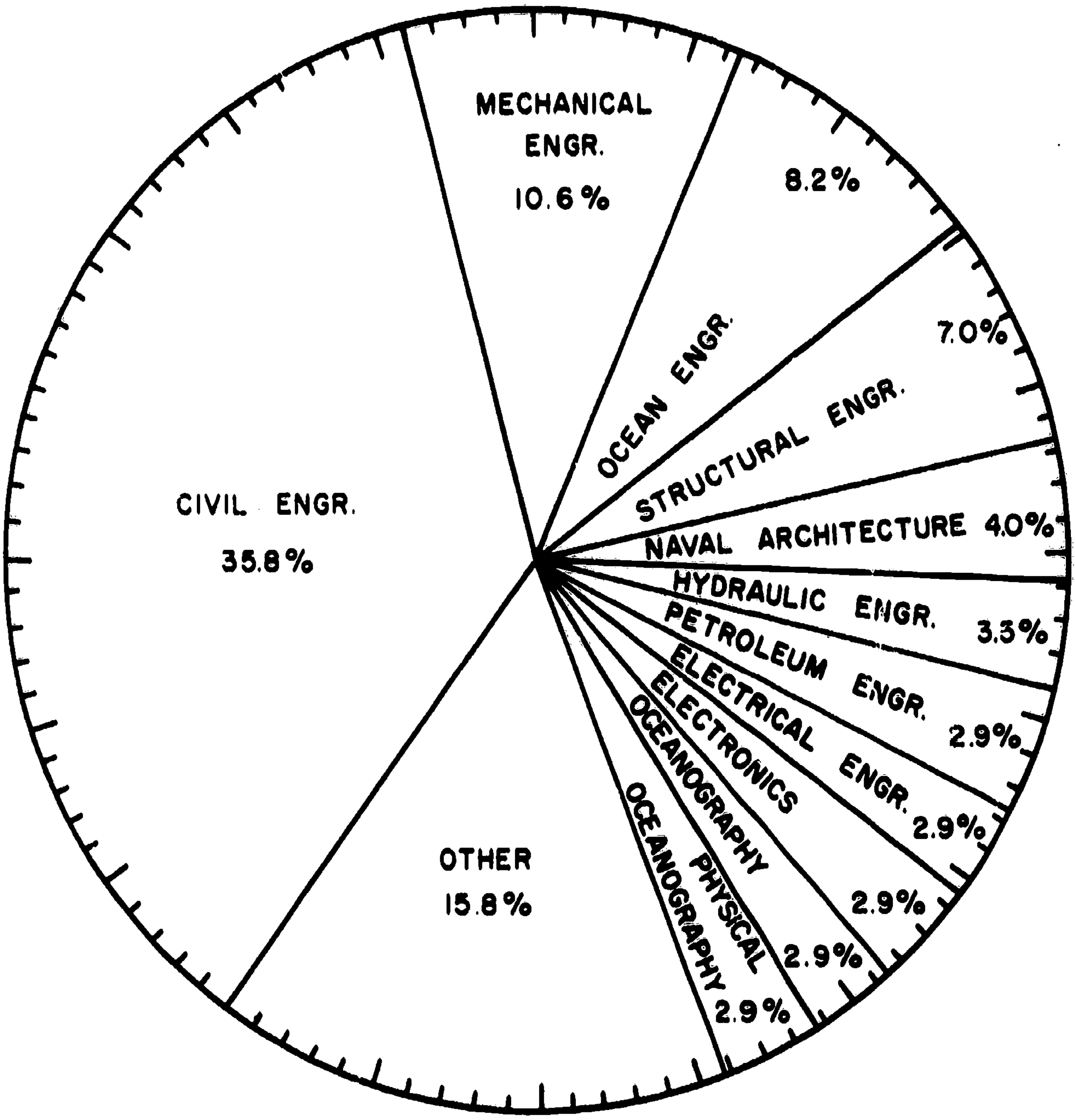
FIGURE I

QUESTION 2: Major Field of Study (at highest educational level)

The exact number of respondents in each major field appears in Table II. The list was arranged with respect to size, beginning with the largest.

The list was then reduced to percentages for a graphical representation (see Figure 2). Accordingly, the major fields of formal education included civil engineering (35.8%), mechanical engineering (10.6%), ocean engineering (8.2%), structural engineering (7.0%), naval engineering (4.0%), hydraulic engineering (3.5%), petroleum engineering (3.5%), electrical engineering (2.9%), eletronics (2.9%), oceanography (2.9%), physical oceanography (2.9%), and others (15.8%).

It is significant to note that the majority of those now working in ocean engineering had formal training in several established fields of engineering (notably civil engineering) or science.



QUESTION 2. MAJOR FIELD OF STUDY

FIGURE 2

CIVIL ENGINEERING - 61

MECHANICAL ENGINEERING - 18

OCEAN ENGINEERING - 12

STRUCTURAL ENGINEERING - 12

NAVAL ARCHITECTURE - 7

HYDRAULIC ENGINEERING - 6

PETROLEUM ENGINEERING - 6

ELECTRICAL ENGINEERING - 5

ELECTRONICS - 5

OCEANOGRAPHY - 5

PHYSICAL OCEANOGRAPHY - 5

MANAGEMENT - 3

MARINE GEOLOGY - 3

MINING ENGINEERING - 3

AEROSPACE ENGINEERING - 2

CHEMISTRY - 2

GEOLOGY - 2

MECHANICS - 2

PHYSICS - 2

SOIL MECHANICS - 2

WATER RESOURCES - 2

ARCHITECTURE CONSTRUCTION - 1

ARCHITECTURE ENGINEERING - 1

ARTS - 1

CHEMICAL ENGINEERING - 1

TABLE III

MAJOR FIELD OF RESPONDENTS

QUESTION 3: Total Number in your organization

The answers for this question ranged from one person (a consultant) to 45,000 employees. The chart below shows the total number of employees and the approximate average of the percentage of people engaged in ocean engineering activities. Also shown are the total number of companies which fall within each category. Information from question four was also used in preparation of this chart.

Total No. Employees	Ave. Percentage Employed in Coastal Engr. (approx.)	No. Companies
1-10	100%	21 (12%)
11-100	30%	44 (26%)
101-1000	$\leq$10%	60 (36%)
>1000	$\leq$ 5%	45 (26%)

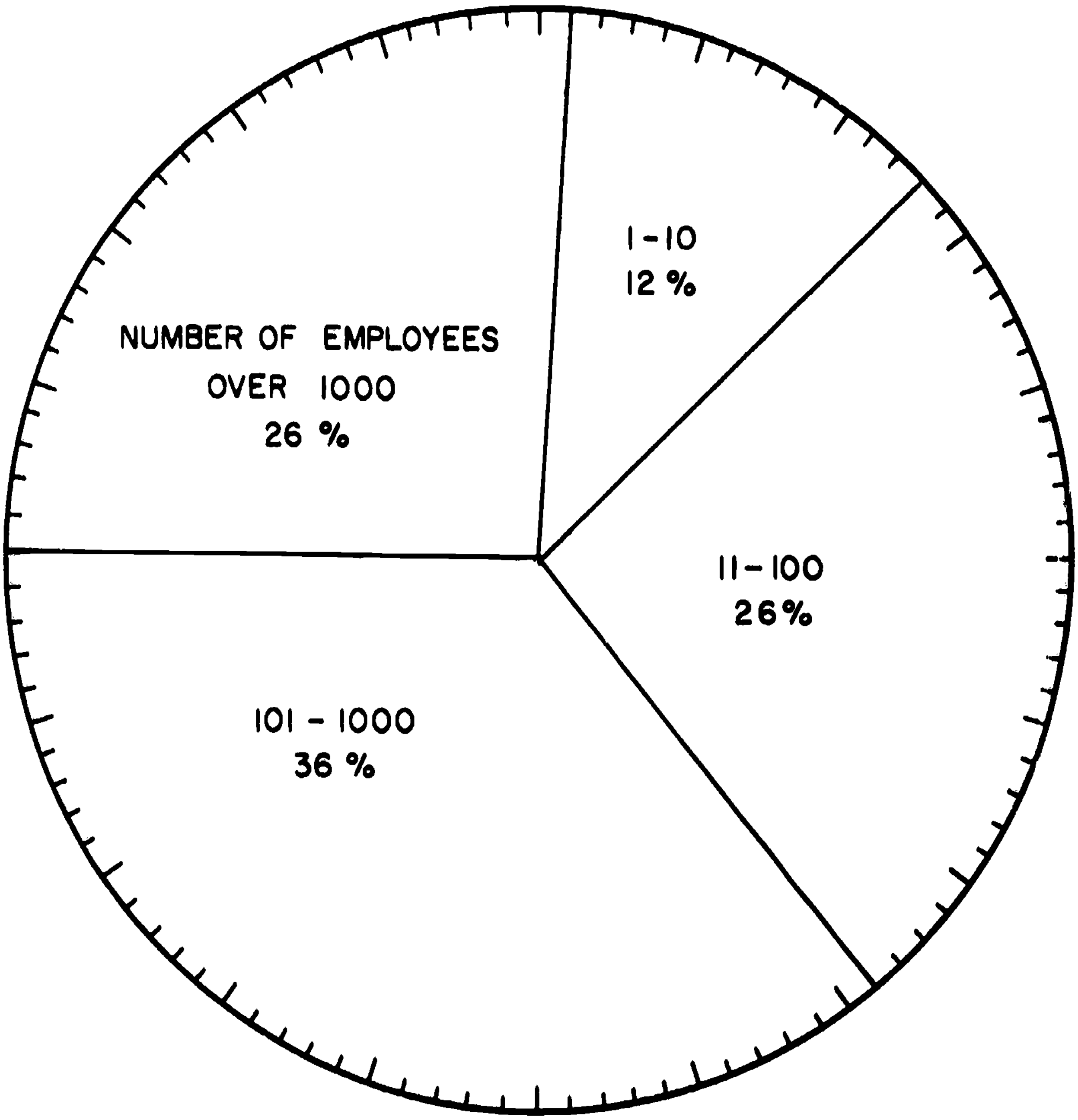
TABLE III

TOTAL NUMBER OF EMPLOYEES

The majority of companies employing less than ten people seem to be completely involved in ocean engineering projects, while the larger the company the greater the diversification. (Figure 3)

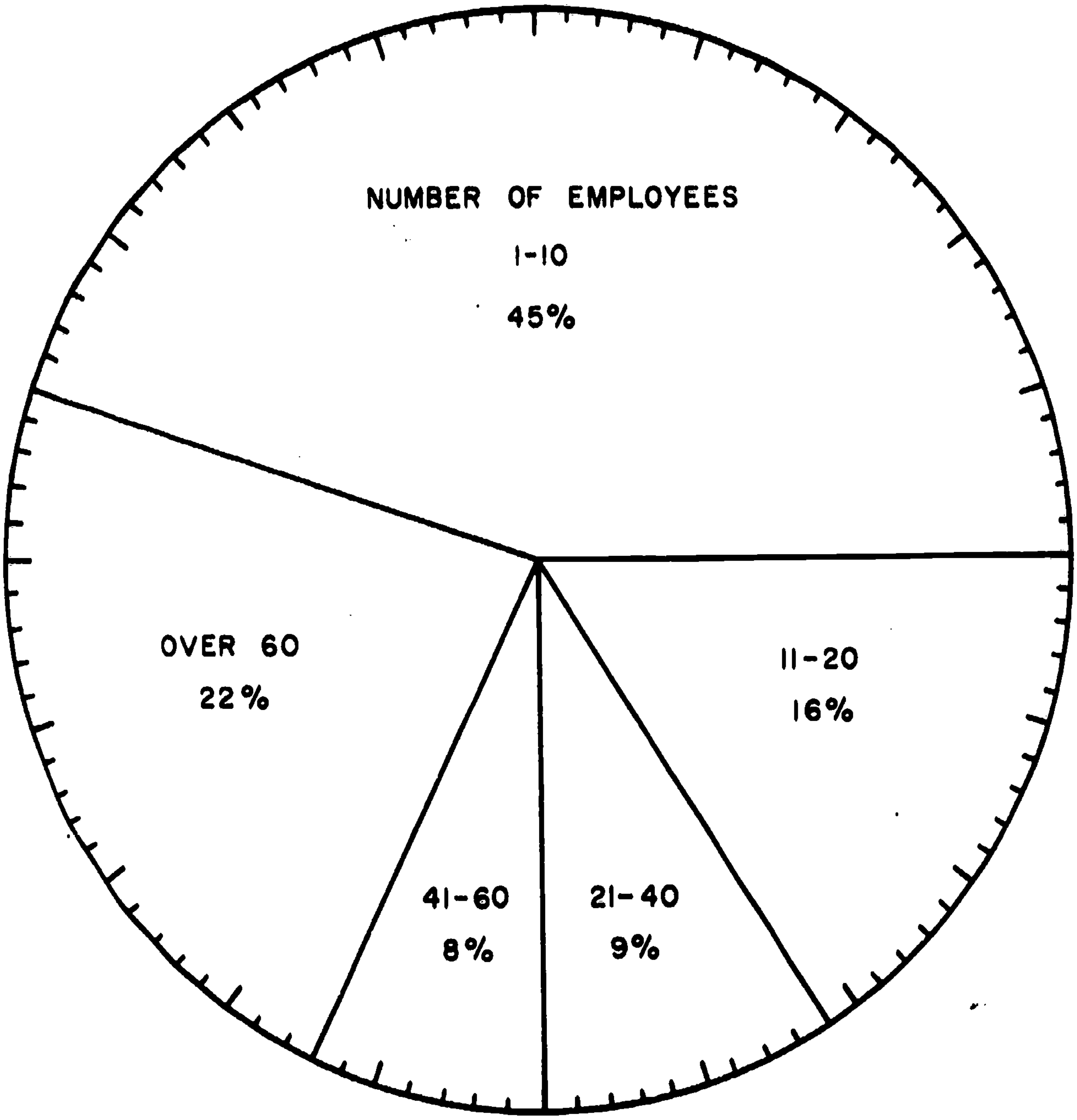
QUESTION 4: Number of Employees working in Ocean Engineering Field

As was shown in question 3, the majority of companies are not completely involved in ocean engineering activities. Instead, most industries have only a portion of their employees working in an ocean engineering field. The total number of employees involved in ocean engineering activities in their respective organizations were as follows:



QUESTION 3. TOTAL NUMBER OF EMPLOYEES

FIGURE 3



QUESTION 4. TOTAL NUMBER OF EMPLOYEES WORKING IN OCEAN ENGINEERING FIELD

FIGURE 4

Number of Employees	Number of Organizations
1-10	77 (45%)
11-20	27 (16%)
21-40	15 (9%)
41-60	14 (8%)
over 60	37 (22%)

TABLE IV

TOTAL NUMBER OF EMPLOYEES WORKING IN OCEAN ENGINEERING FIELD

Note: This is also shown graphically in Figure 4.

It is significant to note that the firms involved in ocean engineering are rather small and employ between 1-10 employees, or are very large, employing over 60 employees. This probably means that the smaller firms are involved in feasibility studies, research and development, and consulting, while the larger firms are involved in petroleum exploration, construction, or production.

QUESTION 5: I Am Working in the Sub-field of . . .

This question was equipped with several multiple choice answers and a blank space for those fields not listed.

Generally, each individual listed more than one field. This would seem to indicate that most jobs in ocean engineering do not specialize in any one particular sub-field.

The sub-field listed on the questionnaire evoked the following responses:

Sub-field	% Working in Sub-field
Ocean Engineering	16.4
Coastal Engineering	11.7
Ocean Foundation	10.3
Ocean Pipelines	9.5
Dredging	7.9
Estuary Engineering	7.4
Ocean Surveys	7.2
Ocean Transportation	5.8
Physical Oceanography	5.8
Submersibles	4.8
Ocean Communications	2.7
Others	10.5

TABLE V

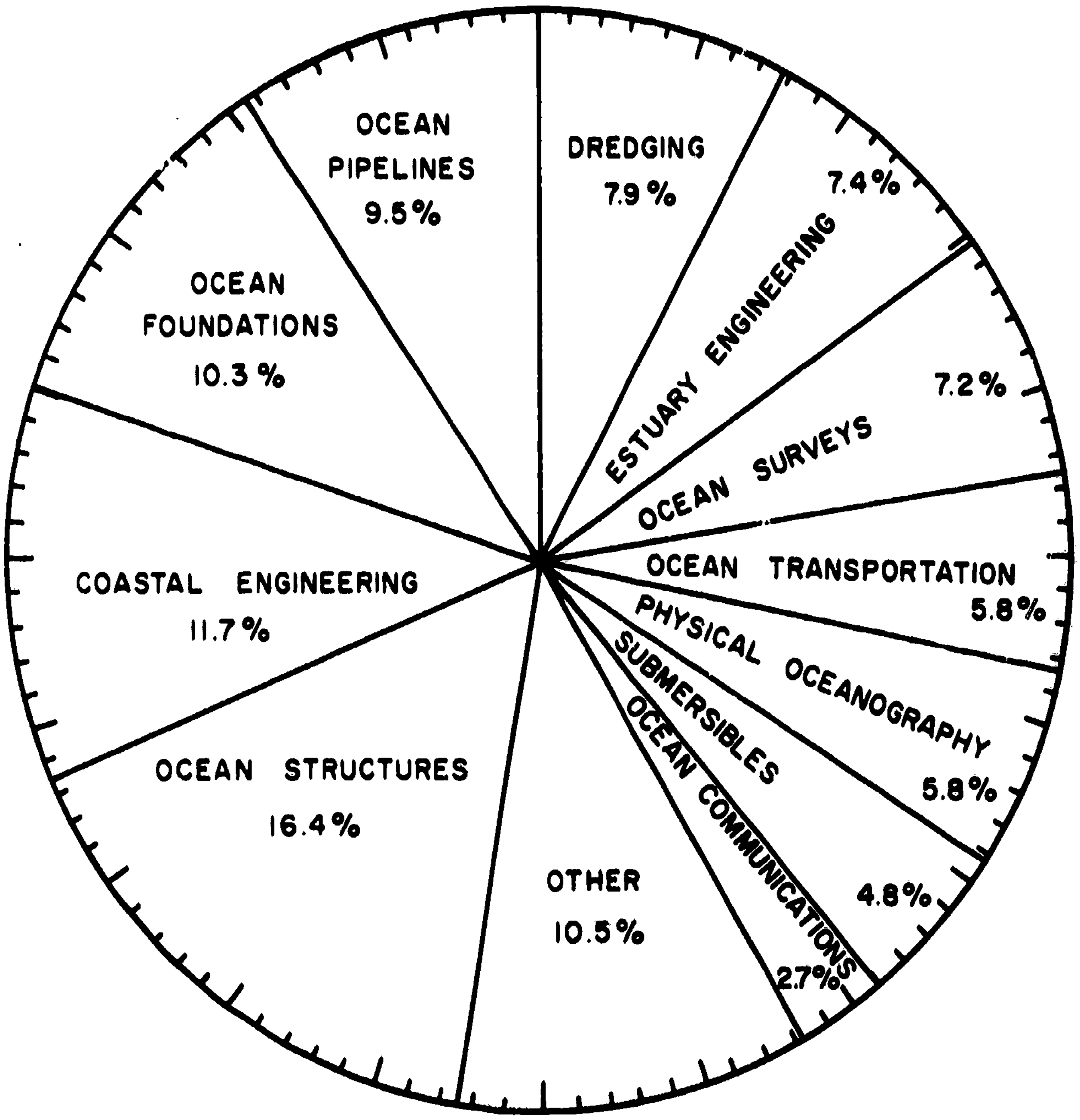
MAJOR SUB-FIELD

Note: This is also shown graphically in Figure 5.

The row entitled "others" includes the fields in which the individual works, but which were not listed on the questionnaire. A detailed listing is given in Table VI.

It is of interest to note that a large percentage of respondents were involved in offshore work (ocean structures, foundation, pipelines) totaling 36.2%. The next large group was involved in work closer to the coast (coastal, estuary engineering, dredging) totaling 27.0%. The third large group could be called the services group. This would include those working alongshore and

offshore (ocean surveys, ocean transportation, physical oceanography, submersibles, and ocean communication) totaling 26.3%.



QUESTION 5. SUBFIELDS OF RESPONDENTS

FIGURE 3

POLLUTION CONTROL - 6

OCEAN MINING - 5

OCEAN INSTRUMENTATION - 4

DESIGN, CONSTRUCTION & OPERATION OF OFFSHORE DRILLING VESSELS - 3

FLOATING DRILLING EQUIPMENT - 2

GEOLOGICAL RESEARCH - 2

MANAGEMENT CONSULTING - 2

MARINE CONSTRUCTION EQUIPMENT - 2

SUBSEA PRODUCTION FACILITIES - 2

ACOUSTICS - 1

APPLIED RESEARCH - 1

AUTOMATIC DATA BUOY 40' DIA. DISCUS - 1

CABLE SYSTEMS - 1

COASTAL RESOURCES - 1

DEEP OCEAN ELECTRONICS - 1

DESIGN CONSTRUCTION OF CARGO, TERMINALS, WHARVES, MOORING STRUCTURES IN ESTUARINE LOCATIONS - 1

DYNAMICS OF SHIPS AND FLOATING PLATFORMS

ECOLOGICAL IMPACT - 1

ECOLOGY - 1

ECONIMICS - 1

HARBOR ENGINEERING & PORT - 1

INTERACTION BETWEEN WAVES AND STRUCTURES - 1

LIFE SUPPORT OIL CONTROL - 1

TABLE VI

"OTHER" SUB-FIELDS

MANAGEMENT - 1

MARINE SOIL MECHANICS - 1

MILITARY - 1

MINERAL EXPLORATION - 1

MOBILE PLATFORM PROPULSORS - 1

OCEAN DATA MANAGEMENT ACOUSTICS - 1

OCEAN DIVING - 1

OCEAN EMPLACEMENT - 1

OFFSHORE PIPE CUTTING - 1

OIL EXPLORATION - 1

PLANNING - 1

REMOTE SENSING - 1

RESEARCH MOORING & WAVE FORCES - 1

SALVAGE - 1

UNDERWATER CONSTRUCTION DIVING SYSTEMS - 1

WAVE DYNAMICS - 1

TABLE VI (CONT.)

"OTHER" SUB-FIELDS

QUESTION 5: Product of Work

This question also provided multiple choice answers in order to save respondent's time. The choices listed, and results received were as follows:

Product	% Working on Product
Conceptional or Feasibility Studies	30.5%
Design	30.2%
Construction	19.6%
Services	13.2%
Others	6.5%

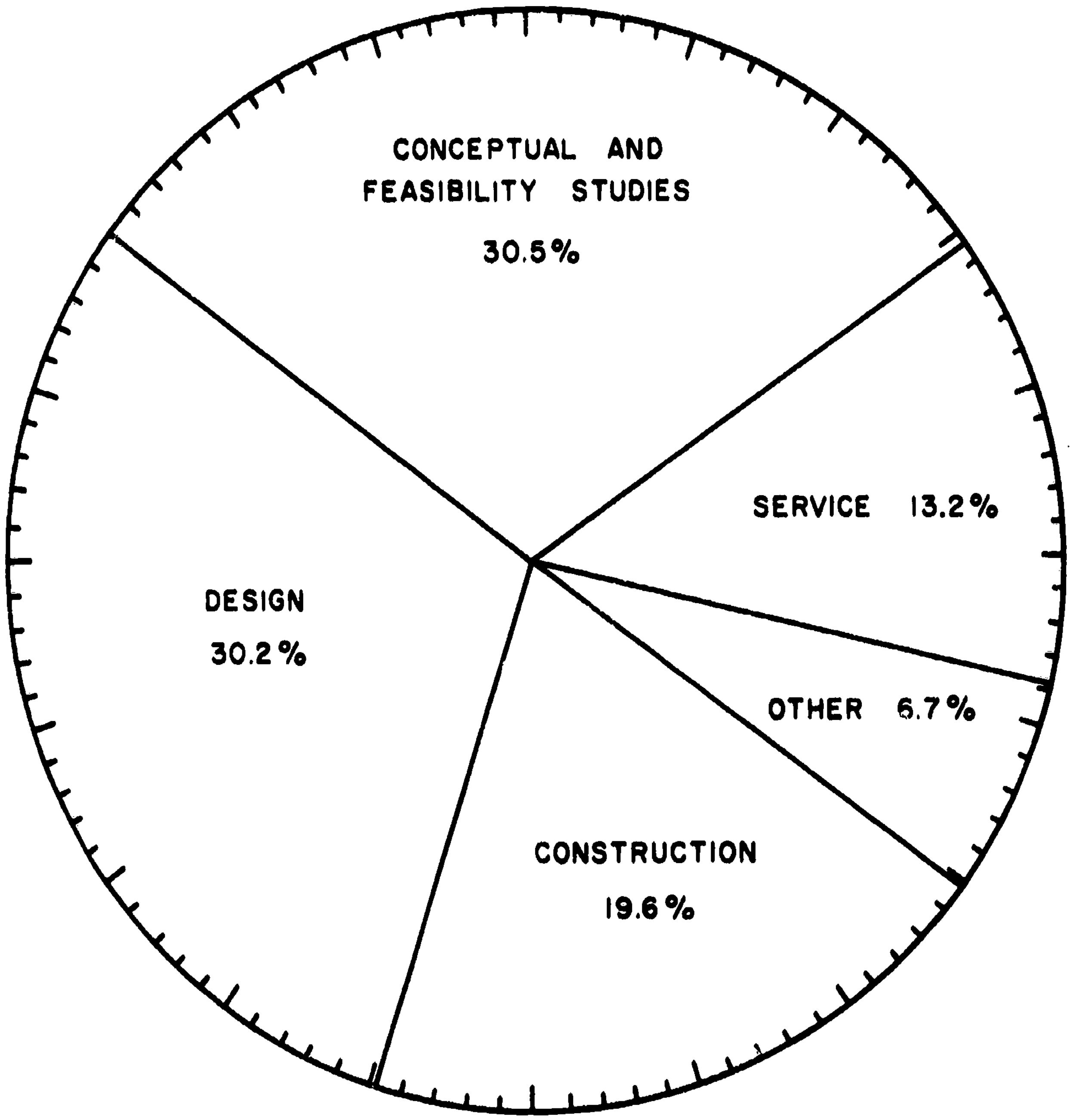
TABLE VII

PRODUCT OF WORK

Note: Also shown graphically in Figure 6.

The category entitled "others" was filled in by the individuals whose product did not precisely fit into any of the above categories. A list of these products is shown in Table VIII.

It is significant to note that a large percentage of respondents (30.5%) were involved in conceptual, or feasibility studies, which is not surprising in a new developing field such as ocean engineering. The largest group was involved in design and construction (49.8%), while services and others totaled 19.7%.



QUESTION 6. PRODUCT OF WORK

FIGURE 6

RESEARCH AND DEVELOPMENT - 4

CONSULTING - 3

MODEL STUDIES - 2

MODEL TESTING - 2

OPERATION AND MAINTENANCE DEVELOPMENT - 2

RESEARCH - 2

ALL OF THE ABOVE - 1

BASIC RESEARCH - 1

COASTAL EROSION CONTROL - 1

CONTRACT AND OPERATIONS - 1

ECONOMIC ANALYSES - 1

EQUIPMENT - 1

ESTABLISHMENT OF DESIGN METHODS - 1

INVESTIGATIONS - 1

OCEAN MINING - 1

OFFSHORE DRILLING AND PRODUCING - 1

PROCESSING DEVELOPMENT - 1

PUBLICATIONS - 1

REAL TIME DATA - 1

SALES - 1

SURVEYS - 1

TEACHING - 1

TESTING AND EVALUATION - 1

TABLE VIII

"OTHER" PRODUCTS OF WORK

PART II. Training in Ocean Engineering

This section dealt with the viewpoint of industry regarding the subject matter which they believed should be included in an ocean engineering program.

The first question asked in this section queried whether or not ocean engineering should be taught on the undergraduate level; only on the graduate level; or taught on both levels. The majority of those surveyes stated that ocean engineering should be taught at both the undergraduate and graduate levels (78.5%), while a minority (21.5%) stated it should be taught only on the graduate level.

It may be concluded that ocean engineering should be taught on both the undergraduate and graduate levels.

The section on training was sub-divided into two parts:

1) The undergraduate curriculum,

2) The Master's Degree program.

(a) *The Undergraduate Curriculum*

Those individuals who believed that ocean engineering should be taught only on the graduate level generally did not answer the questions under this heading. Those who did agree were asked if the curriculum should be comparable to other engineering degrees which would consist of basic sciences, applied sciences, and humanities. Ninety-four percent agreed with this approach.

In response to a question regarding the type of courses to be included in the curriculum, the following were specified: (also summarized in Table IX)

A. Basic sciences

B. Core material including information on

1) Ocean environment

2) Material behavior

3) Human factors

4) Communications

C. Applied sciences including engineering in, or of

1) Shore

2) Estuaries

3) Offshore

4) Deep ocean

5) Measurements

6) Aquaculture

7) Ecological effects

Priorities in the selection of subject matter are shown graphically in the following pages. It should be noted that the subject matter in the applied science category was arranged according to the following priorities: (also summarized in Table X).

1. Offshore
2. Shore
3. Estuaries
4. Deep ocean
5. Measurements
6. Communications
7. Economics
8. Aquaculture
9. Other

(a) BASIC MATERIAL

BASIC SCIENCES (99.5% AGREED)

(b) CORE

OCEAN ENVIRONMENT	(99.5% AGREED)
MATERIAL BEHAVIOR	(96%)
HUMAN FACTORS	(76%)
COMMUNICATIONS	(75%)

TABLE IX

BASIC MATERIAL: B.S. CURRICULUM

APPLIED SCIENCE

SHORE AND ESTUARIES	(93.5% AGREED)
OFFSHORE	(99%)
DEEP OCEAN	(87%)
MEASUREMENTS	(91%)
AQUACULTURE	(51%)
ECOLOGICAL EFFECTS	(85%)

PRIORITIES

1. OFFSHORE
2. SHORE
3. ESTUARIES
4. DEEP OCEAN
5. MEASUREMENTS
6. COMMUNICATIONS
7. ECONOMICS
8. AQUACULTURE
9. OTHER

TABLE X

APPLIED SCIENCE AND PRIORITIES: B.S. CURRICULUM

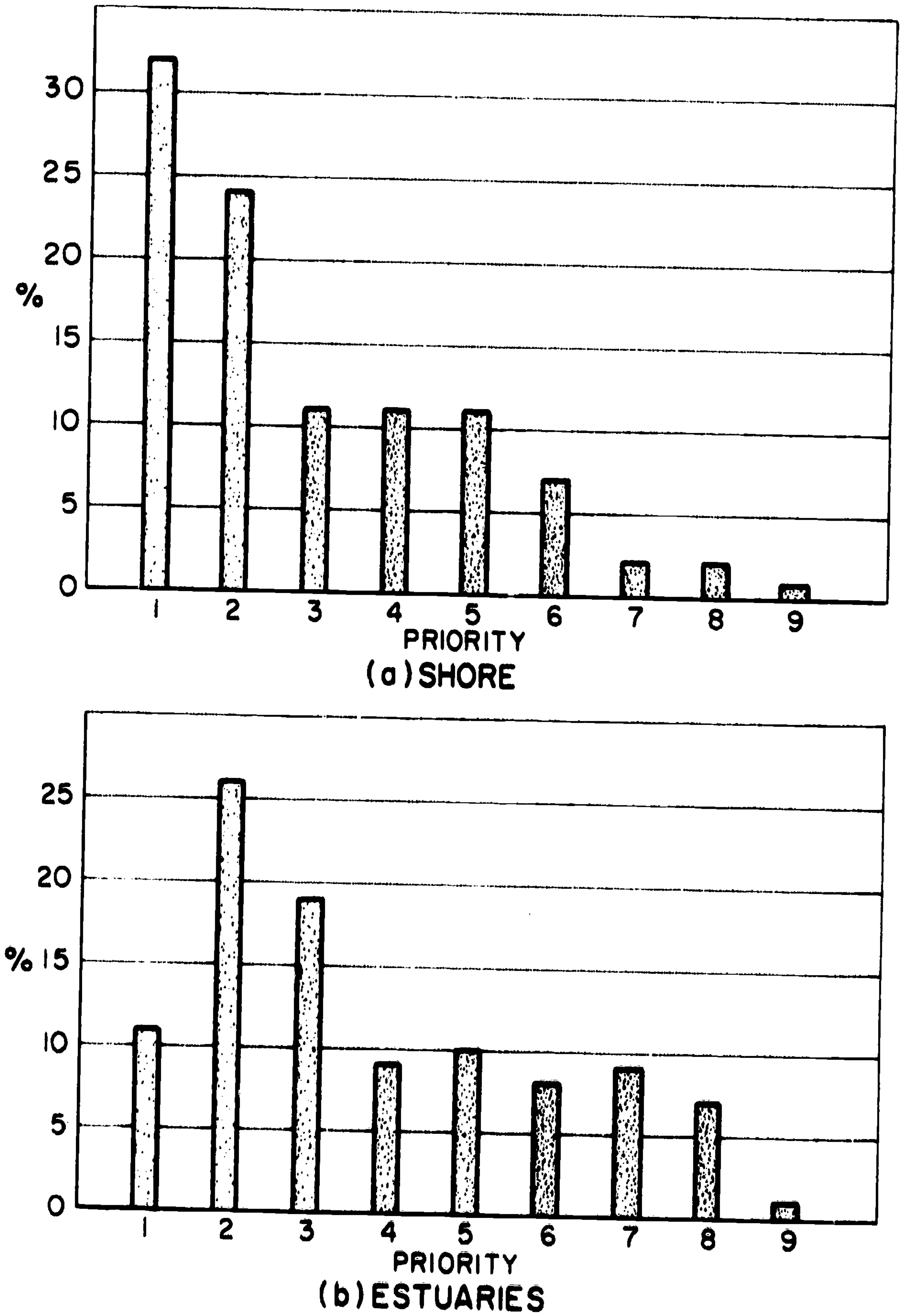


FIG. 7 UNDERGRADUATE CURRICULUM-PRIORITIES IN APPLIED SCIENCE CATEGORY

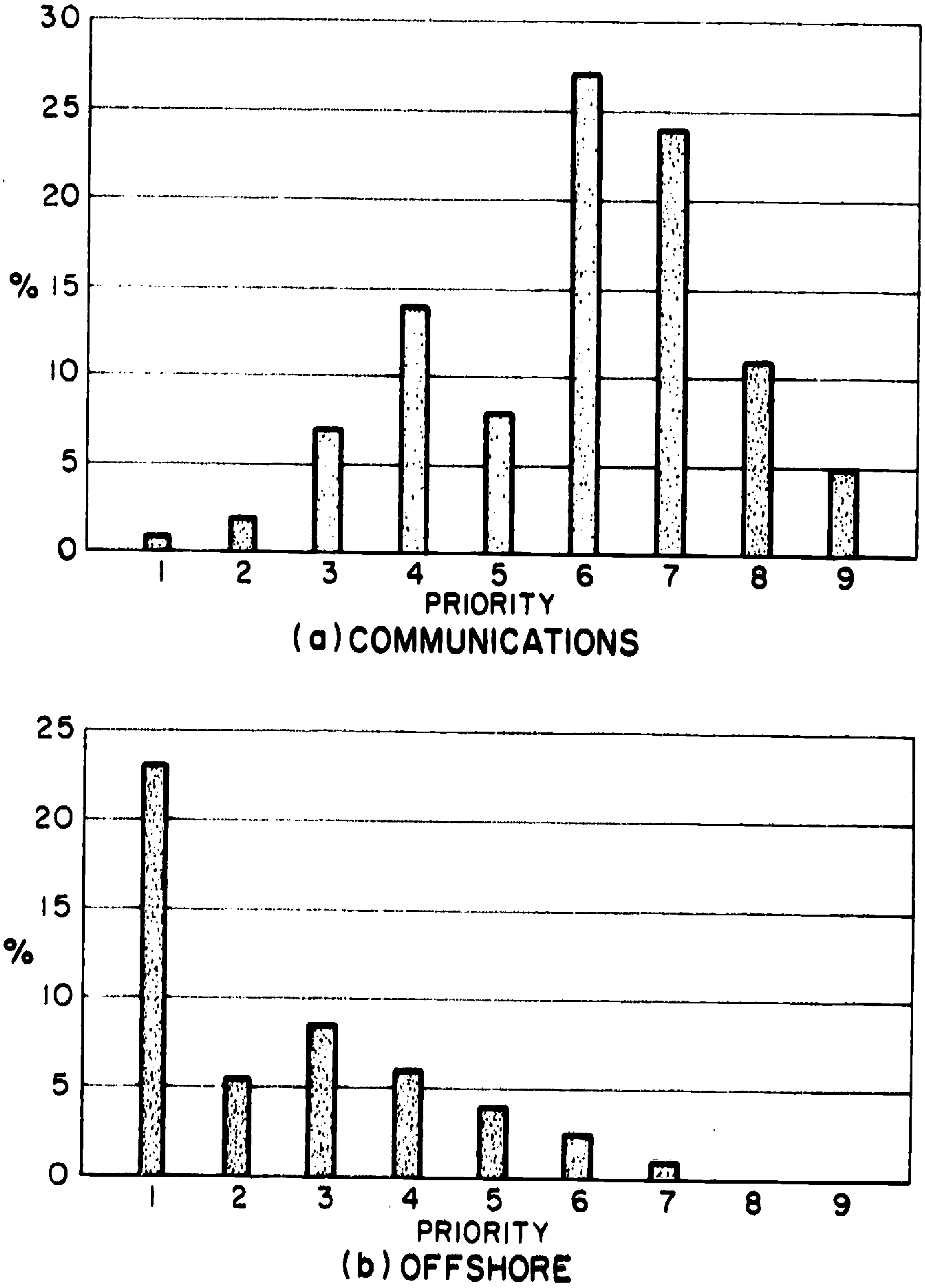


FIG. 8 UNDERGRADUATE CURRICULUM-PRIORITIES IN APPLIED SCIENCE CATEGORY

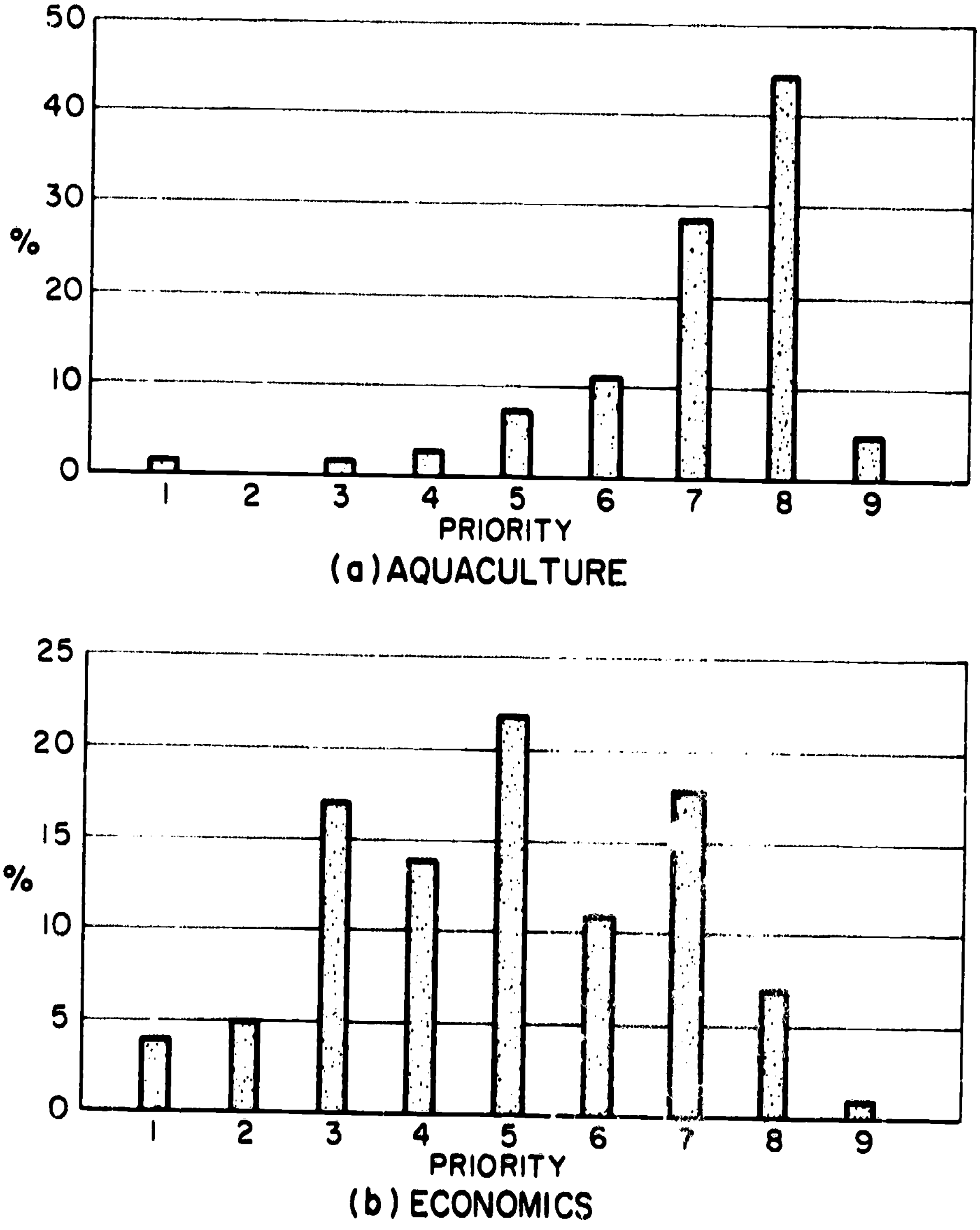
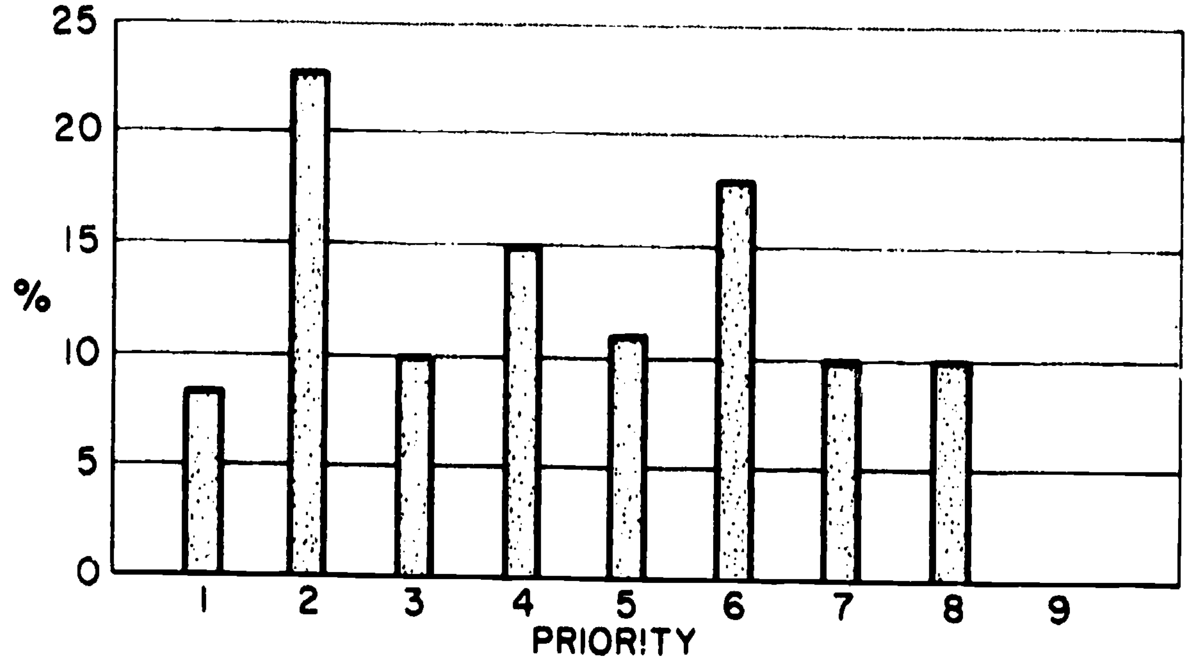
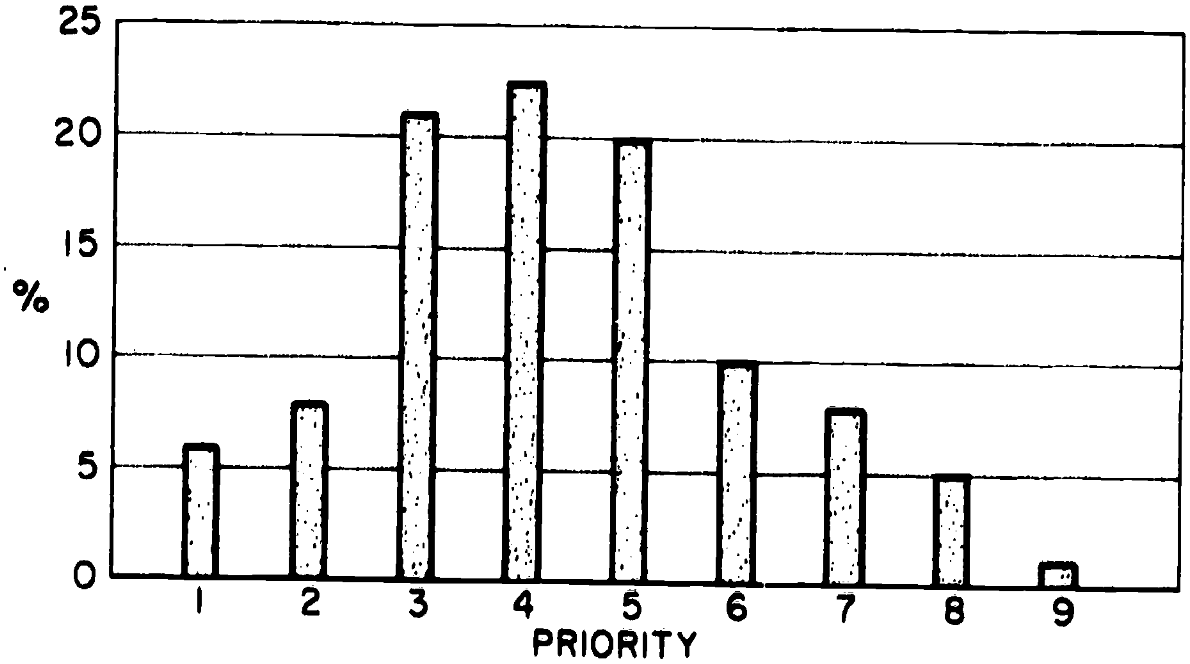


FIG. 9 UNDERGRADUATE CURRICULUM-PRIORITIES IN APPLIED SCIENCE CATEGORY



(a) DEEP OCEAN



(b) MEASUREMENTS

FIG. 10 UNDERGRADUATE CURRICULUM-PRIORITIES IN APPLIED SCIENCE CATEGORY

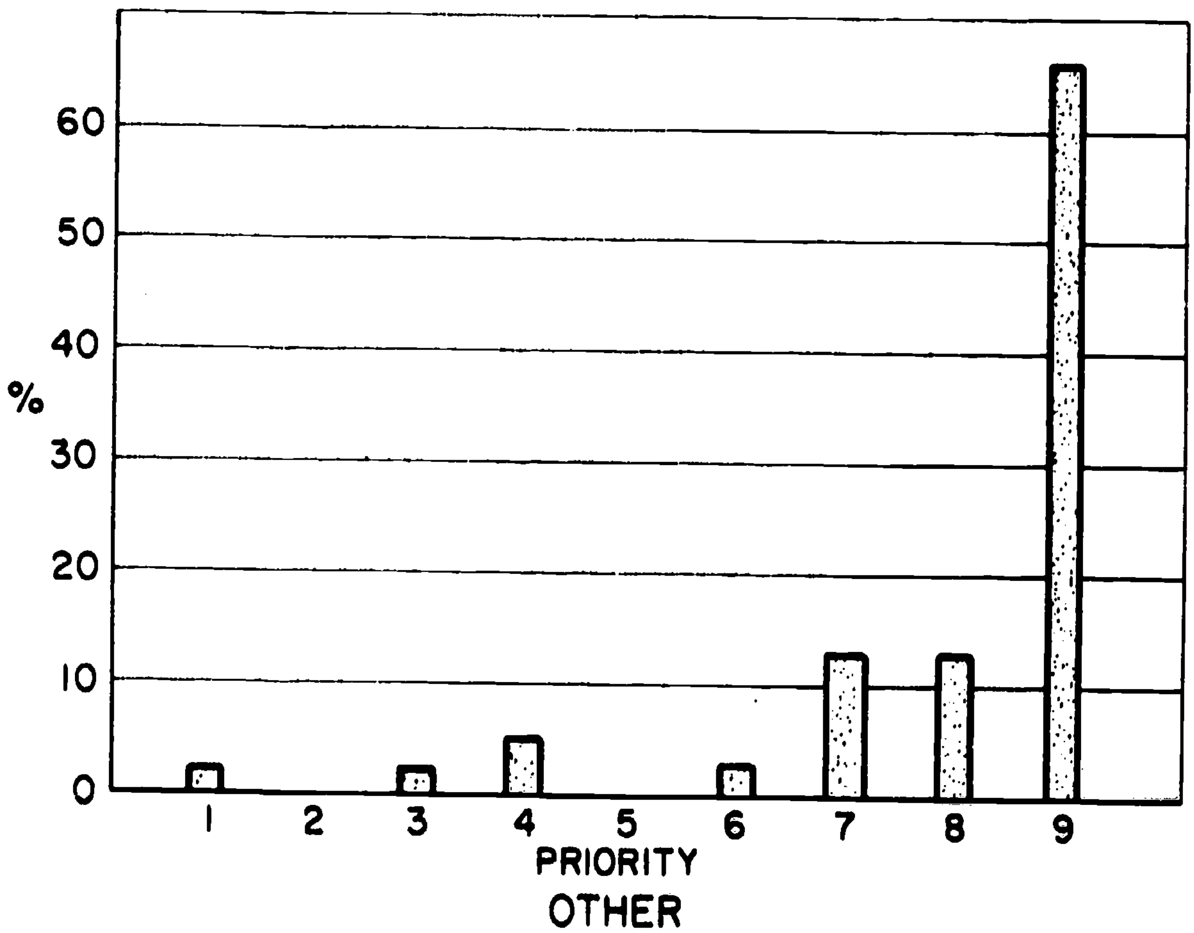


FIG. 11 UNDERGRADUATE CURRICULUM-PRIORITIES IN APPLIED SCIENCE CATEGORY

Question 9 of the survey was reserved for general comments. Any opinions not covered in the questionnaire were invited. The general consensus was that the basics of engineering should be emphasized even more so, but practical experience and training were also recommended.

The following comments were taken from question 9 on the survey.

COMMENTS RECEIVED IN MAIL QUESTIONNAIRE

Question 9(e)

Please give any general comments regarding the undergraduate curriculum which may help us in evaluating the industrial viewpoint.

Include strong mathematics background.

All items in 9(b) and (c) are important. Some should be presented in the first basic courses and then the student permitted to branch into areas which appeal to his interests.

The curriculum should be designed to fit the requirements that are unique in the ocean environment.

Ocean Engineering while exciting does not employ many people. Employment is mainly in the Petroleum Industry. I suggest that the basic disciplines be followed, with some time devoted to applying them in the ocean environment.

Practical application to typical problems encountered by Corps of Engineers in their Civil Works Program in regard to navigation and beach protection projects.

Students should receive compulsory practical experience of at least 12 months (altogether) before receiving degree.

Computer science a must.

Show reasoning behind Government financing, interest, hopes, etc., and stress technological problems that emphasis is being directed towards - whether it be submarine detection/escape, coastal land preservation or offshore mining.

As I am in planning I would not speak from authority.

75% of effort of my section is dedicated to structural analysis in offshore environment.

5 year program for B.S. - include considerable in-situ, i.e., at sea work experiences - you cannot appreciate the problems of ocean engineering until you have been to sea and tried to make-it-work.

More hardware technology should be taught.

Background in mathematics and basic engineering fundamentals is absolutely essential.

Undergraduate training in civil, mechanical, or electrical engineering is needed with graduate study in ocean engineering.

Give as much practical instruction as possible by men who have worked on the water.

The undergraduate curriculum should be limited to giving a broad overview of most of the aspects of ocean engineering. Depth studies and specialization should be reserved for the graduate level.

Temper theory with practical reality. Economic as well as physical feasibility.

Marine and ocean engineering is a complex amalgam of many disciplines. I would think that it would be best to stick to basics in an undergraduate program, (e.g., math, strength of materials, physics, mechanics) and offer only a few introductory ocean engineering courses. There is not enough time for undergraduates to pick up the broad variety of knowledge needed by a good ocean engineer.

9a - 9d are not answered because I do not feel that a student should specialize in ocean science/engineering as an undergraduate. The four years could be well spent in the engineering fundamentals as they are now taught.

Graduates should have a basic understanding of the "state of the art" for the field of ocean engineering he plans to enter.

I would think that, in order to cover the basic engineering courses, the ocean engineering portion of the program would be limited to perhaps 30 semester credits, as a maximum. In an undergraduate curriculum, it would at least give the student a taste for further study in graduate school.

At undergraduate level, I would recommend only one to three courses introducing the subject with special emphasis on the inter-disciplinary aspects.

Detailed training in the basic sciences is more important than peripheral items (specialties) which can best be learned on the job.

Try to introduce as much practical information and experience as possible. Maintain close liaison with industry as to "real" problems, etc.

I believe strong emphasis should be maintained in the basic sciences, applied sciences, mathematics and humanities at the undergraduate level, with ocean engineering being given on an introductory basis within the framework of a student's chosen field of engineering or science.

Our interest is in engineers for waterfront work.

A good understanding of physics and engineering provide the best tools for our use.

Answers above are appropriate only if an undergraduate curriculum is developed. At present, we feel that there is no need for another breed of undergraduate engineering program.

Teach basics.

Engineers should have basic knowledge and be ready to go to work. The idea that most engineers are managers tomorrow is not good to impress the new engineer with at time of graduation.

Emphasis on fundamentals - science, mathematics and basic technologies of materials, information processing and energy conversion and utilization.

Ocean engineering is such a broad field, that for an undergraduate course, it should be subdivided into fields of specialization as the land engineering fields.

So far as this organization is concerned, the requirement is for graduates with good general civil engineering knowledge, sufficient general knowledge of ocean processes and their effects on engineering works to become expert with experience. Post graduate study either formal or personal.

1st year Basic Engineering, Calculus & Humanities, 2nd year, Fluid Mechanics, Hydraulics, Hydrology, Sanitary Engineering, Soil Mechanics, Advanced Calculus, 3rd year and 4th year - Coastal & Ocean Engineering that cover the basic topics mentioned in 9-D, Engineering Economics, Management, Engineering Law, Computer & Technical Electives.

Ocean Engineering is an interdisciplinary field. A student should have a good overview but with some other major to start his career.

Undergraduates should be exposed to marine construction in a broad course i.e., one which would include (but not be limited to) drilling, tunneling, dredging, erosion control, mining, engineering, etc. This in the sophomore or freshman year so that they might develop interests in specific fields of ocean and coastal engineering. The result being that perhaps more of these men would participate in summer exercises or jobs which would be related to the line of study.

Keep it people-oriented.

In coastal engineering, the human-ecological-environmental aspects of coastal zone management and use should be stressed.

Good basic training in fundamentals.

The needs of my company would favor a practical design emphasis as opposed to a theoretical emphasis.

An undergraduate curriculum in ocean engineering is not desirable. It is better to specialize in a major branch of engineering and do ocean engineering as graduate study.

Interdisciplinary studies of projects.

I believe ocean engineering may be too broad a technical field for undergraduate work, and can best be undertaken with one of the conventional enginering disciplines (BS) as graduate work applying that discipline.

Undergraduate level should be a basic engineering curriculum with only one or two courses in ocean engineering covering the general areas.

General coverage with strong engineering background.

I would encourage a broad based curriculum with the objectives of preparing engineers to work with the ocean environment.

Because activity in ocean engineering can take on such a large variety, and no adequate forecast of skills can be made, a good, general engineering undergraduate curriculum is now more important than a cursory exposure to ocean engineering selected topics.

Our company ordinarily has little work involving ocean engineering, being mostly concerned with heavy industrial structures on land. Our concern for education for a young engineer would be a general overall program rather than specifics.

I believe that the legal aspect should also be considered. Who owns, if anybody, the ocean deposits? How does the U.N. fit into this picture?

The undergraduate curriculum should include a maximum amount of field work. The requirement of at least two summer sessions of work in some related field would provide the student with a realization of some of the practical problems that are experienced in the field.

Emphasis should be placed on the interfacing of surface-oriented concepts to the underwater environment.

A five-year program would be necessary to turn out a first-class product.

Stress basics of engineering.

Foreign language should be included as part of bachelor work.

Humanities, ecology, etc. should be comparable to coverage in other fields of engineering - emphasize basics.

Enclosed is BS - Oceanographic-technology at Lamar Tech which I think helps fill the present gap quite well between the trained civil engineer and the graduate level oceanographer - at least for the present.

Practice in the field to motivate his own interests and design better instruments.

Proper emphasis on coastal and estuarine planning and zoning should be included in the curriculum.

Practical application.

The most important aspect of undergraduate training is a sound background in all the basic sciences. Specialization is not necessary here.

The needs appear to be changing so fast, it would appear desirable to instill a solid basic background, which would be enriched and developed through experience.

Should not be an undergraduate major; however, courses in above could be included for electives for those planning to obtain advanced degree in ocean engineering.

The curriculum should include pollution.

Well trained B.S. and M.S.--type form the working foundation, commercial, applied ocean science. They provide best work performance for reasonable cost to the client.

Stress basics of agents and processes in physical terms for geology, biology and physical oceanography.

I think the undergraduate curriculum is deficient in the area of the environmental and ecological effects of man-made structures.

There are at present too many book engineers wanting to be department heads, and not enough practical type people willing to participate and get their hands dirty.

Please do not overlook the humanities! I also consider that an engineer must be articulate. If he can't write, he cannot prepare a report. Many times what our customers see is the report of tests. The best tests, if not reported properly, are an inferior product.

A broad engineering background with emphasis on practical problems of offshore petroleum and ecology. Specialties should wait for advanced degrees.

Emphasize breadth rather than depth at the undergraduate level.

A program for upgrading or retraining engineers with degrees in other fields would be very useful.

I would stress mechanical or structural engineering as the primary core with ocean engineering as a specialization supplement.

Practical hardware experience and personal performance in the environment is mandatory to make the lecture material meaningful.

At the undergraduate level you should be teaching basic engineering.

Should include a course on the economics of ocean-oriented business. Undergraduates should be warned early about the true economic picture. This course should not be given by an academically-oriented individual but rather by a business man with many years experience.

I see it as training an engineer in a basic engineering discipline with elective courses in the ocean field.

Important to distribute and teach basic information on rigging, mechanical systems, hardware, and practical examples (and problems) in this field.

Need basics as in any engineering field.

Interaction of the various application viewpoints with objective or improved planning.

Universities should do the best they can to forecast demands and avoid overproduction. Universities should give students some ideas of their probability of spending a significant proportion of their careers as productive <u>scientists</u> or <u>engineers</u>. My feeling is that career patterns and demands of industry tend to divert the majority of engineers and scientists away from their professional disciplines.

Having graduated with a B.S. in Ocean Engineering from Florida Atlantic University, I would say that the program should have good courses in acoustics and offshore structures because the only work available in Ocean Engineering is for government contracts and oil companies. The idea of courses in aquaculture sounds great, but you cannot make a living at it now. This questionnaire gives a list of ocean engineering fields and asks if they should be included in Ocean Engineering. In looking for a curriculum for a B.S. degree, I would look at that of Florida Atlantic University. Everything I took has been useful. There should have been more structure courses and wave courses. There should be some good courses on materials and mechanisms in the ocean.

Should include a good mix of basic sciences and applied sciences. New employees must be able to immediately work (along with others) in "real" assignments.

The course should include a design project of some type. Use relative ground rules and mark on practicality of result. About 1/2 one-half of semester work.

Practical courses needed. Omit highly theoretical.

By title, your curriculum appears more theory-oriented than engineering and concerns itself with potentially tomorrow's requirements rather than today's.

Our work--marine construction--builds experience on a basic civil engineering training. I am not certain how any change would be that helpful to us, other than addition of courses on marine structures.

Ocean engineering is probably best treated as a field of emphasis in mechanical engineering, naval architecture, electrical engineering etc. The emphasis or priority would then vary according to the basic course. All courses should have some background in these fields, however.

Minerals, marine biology.

Emphasis on coastal engineering, structures, wave forces, erosion, materials of engineering in salt water and corrosion, fouling and boring, physical oceanography.

I believe the curriculum should allow for basic studies initially with specialization in 4th year onward into graduate years. Division of specialization into (1) shore, aquaculture, ecology, human factors, etc.; and, (2) deep ocean, offshore mining, measurements in second category.

Provide sufficient number of courses so that the student may choose the subject matter most directly related to his long range interest.

Well grounded courses in basic engineering followed by effect of ocean environment on engineering practices.

Practical hardware experience and personal performance in the environment is mandatory to make the lecture material meaningful.

Should contain more practical field work than any other engineering curriculum.

Course content should be high on fluid flow and solids transport in water.

I agree to teaching courses at undergraduate level but I do not agree that a formal degree should be given--this should only occur at a graduate level.

Desirable to have substantial at-sea experience in measurements, dynamics, and practical aspects of platforms, and on-board sample data processing.

The undergraduate curriculum should be planned to cover as wide a field as possible, even though superficial.

Should contain more practical field work than any other engineering curriculum.

(b) *Master's Degree Program*

Those respondents who agreed that ocean engineering should be taught on the graduate level answered these questions. The subject matter which would be included in a Master's Degree program was subdivided into basic material, and applications.

The curriculum for basic material would include:

(1) Physical oceanography

(2) Geological oceanology

(3) Chemical oceanography

(4) Biological oceanology

(5) Hydromechanics

(6) Wave Theories

(7) Computer Programming

(8) Man-in-the-Sea

Asked to give priorities to these basic courses, the respondents selected the following order: (also summarized in Table XI).

(1) Physical Oceanography

(2) Hydromechanics

(3) Wave Theory

(4) Geological Oceanography

(5) Biological Oceanography

(6) Chemical Oceanography

(7) Computer

(8) Man-in-the-Sea

(a) BASIC MATERIAL

PHYSICAL OCEANOGRAPHY	(99% AGREED)
GEOLOGICAL OCEANOGRAPHY	(95%)
CHEMICAL OCEANOGRAPHY	(78%)
BIOLOGICAL OCEANOGRAPHY	(83%)
HYDROMECHANICS	(97%)
WAVE THEORIES	(97%)
COMPUTER PROGRAMMING	(86%)
MAN-IN-THE-SEA	(68%)

(b) PRIORITIES

(1) PHYSICAL OCEANOGRAPHY
(2) HYDROMECHANICS
(3) WAVE THEORIES
(4) GEOLOGICAL OCEANOGRAPHY
(5) BIOLOGICAL OCEANOGRAPHY
(6) CHEMICAL OCEANOGRAPHY
(7) COMPUTER
(8) MAN-IN-THE-SEA

TABLE XI

BASIC MATERIAL AND PRIORITIES: M.S. CURRICULUM

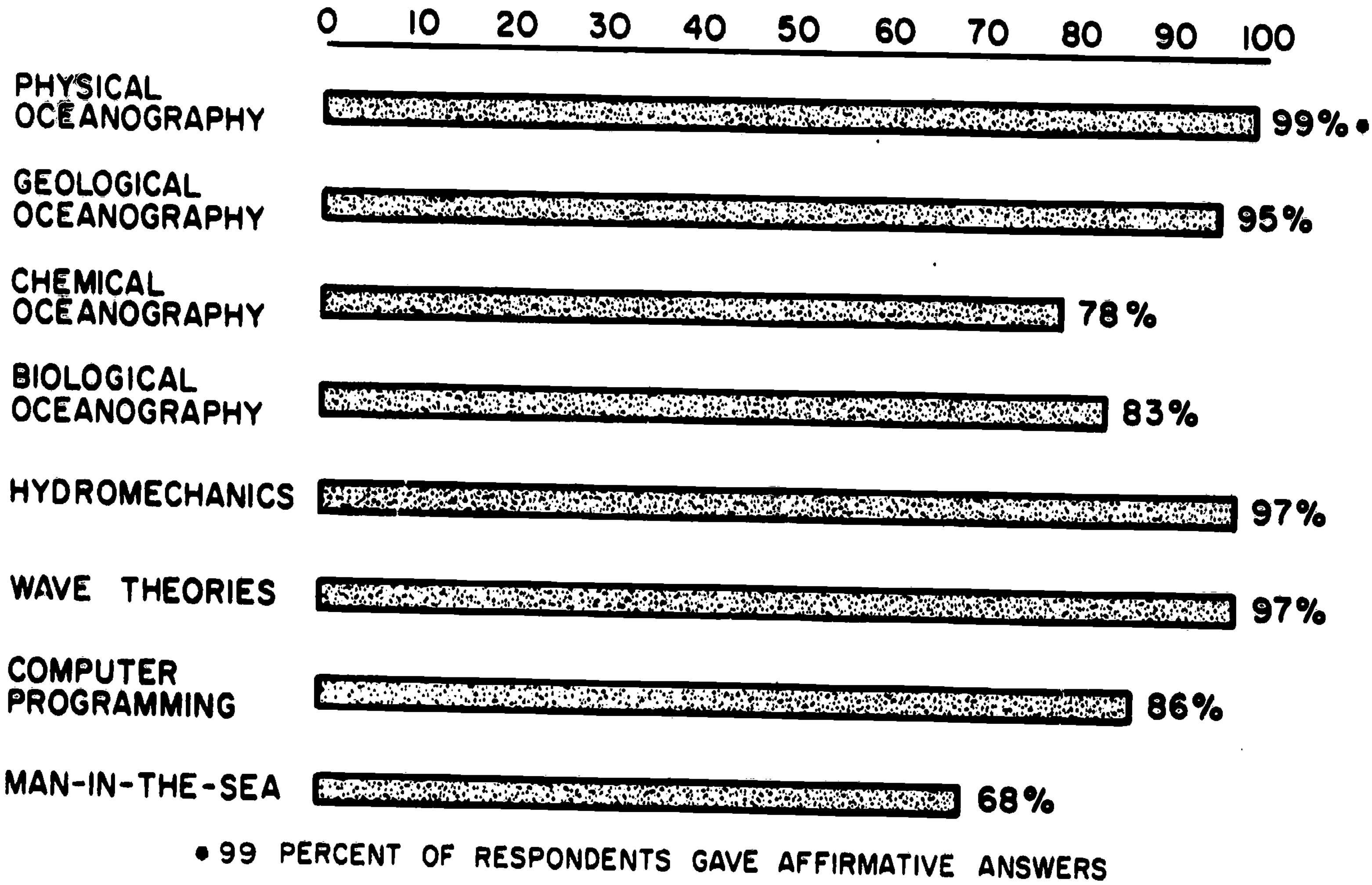
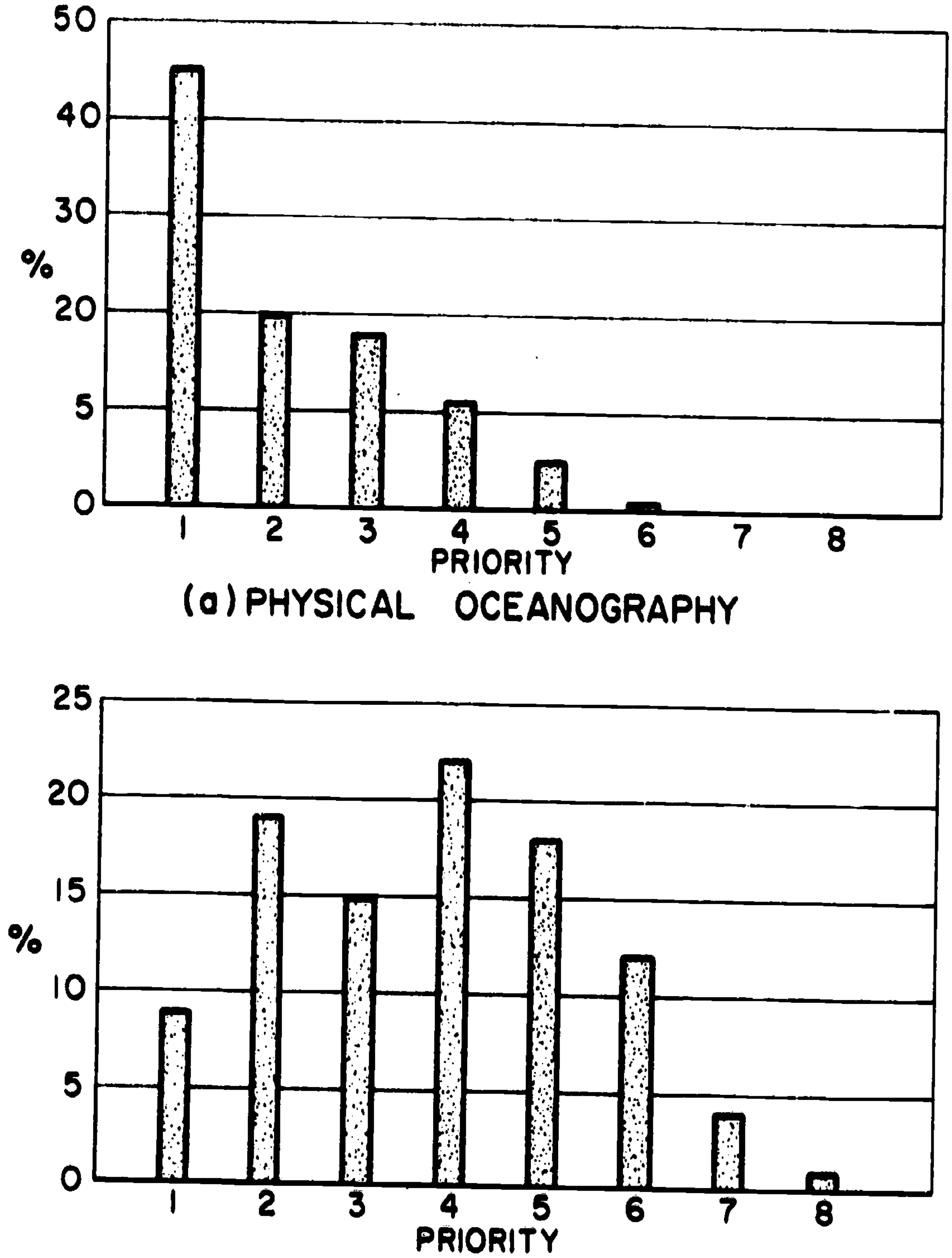


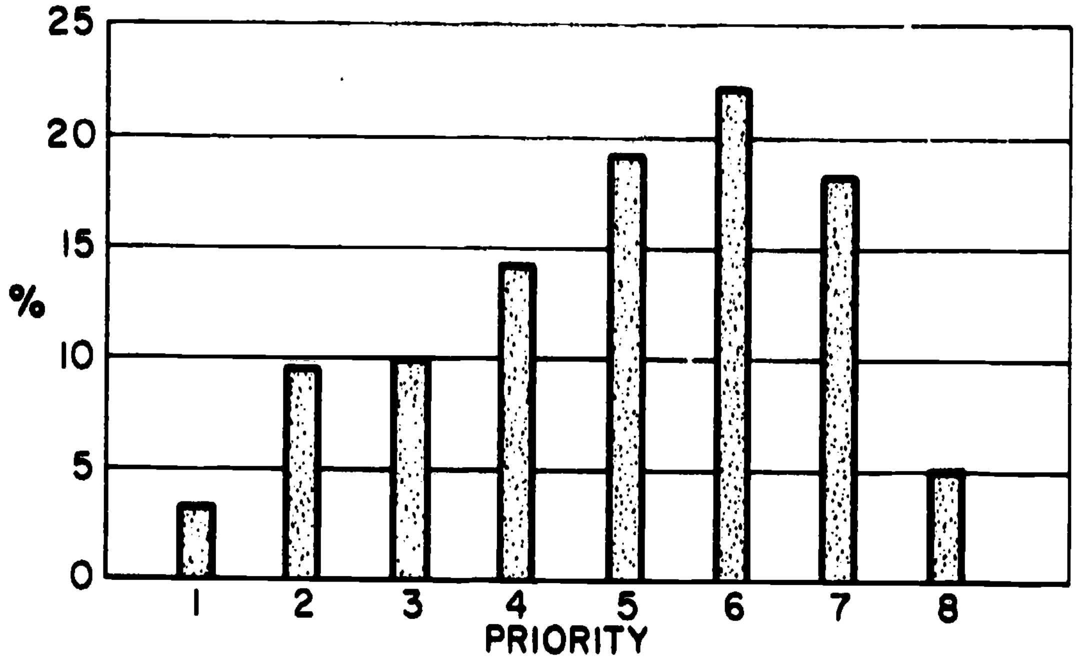
FIG. 12 MASTER'S DEGREE CURRICULUM - BASIC MATERIAL



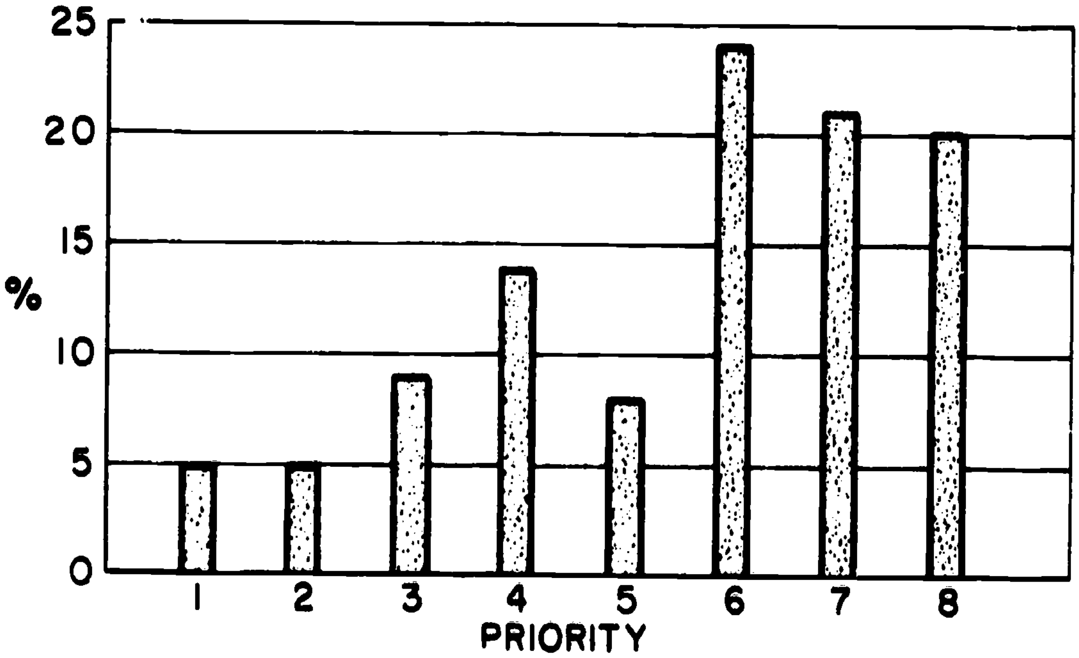
(a) PHYSICAL OCEANOGRAPHY

(b) GEOLOGICAL OCEANOGRAPHY

FIG. 13 MASTER'S DEGREE PROGRAM-PRIORITIES IN BASIC MATERIAL

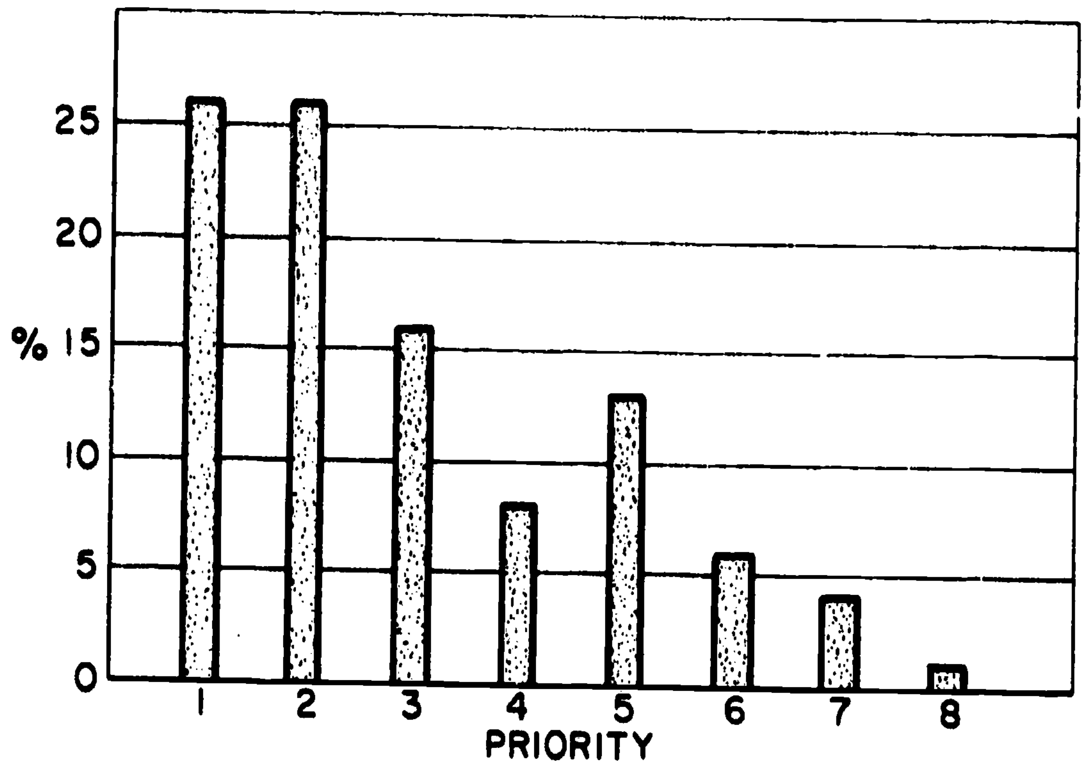


(a) CHEMICAL OCEANOGRAPHY

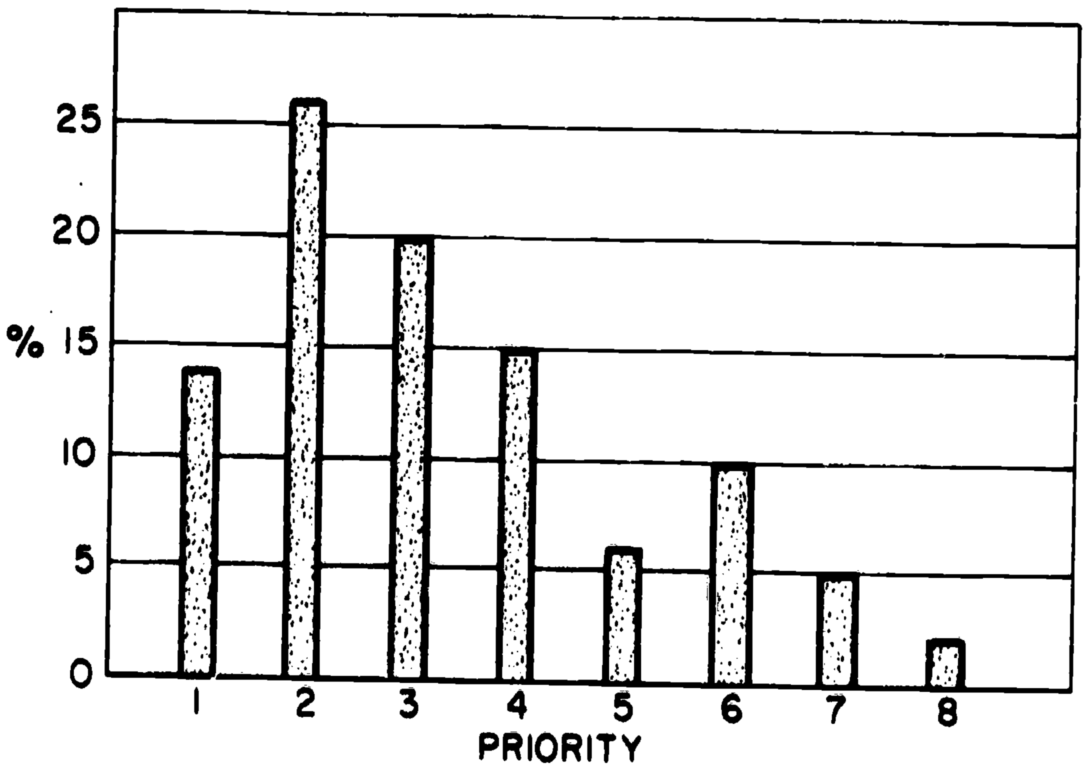


(b) BIOLOGICAL OCEANOGRAPHY

FIG. 14 MASTER'S DEGREE PROGRAM-PRIORITIES IN BASIC MATERIAL

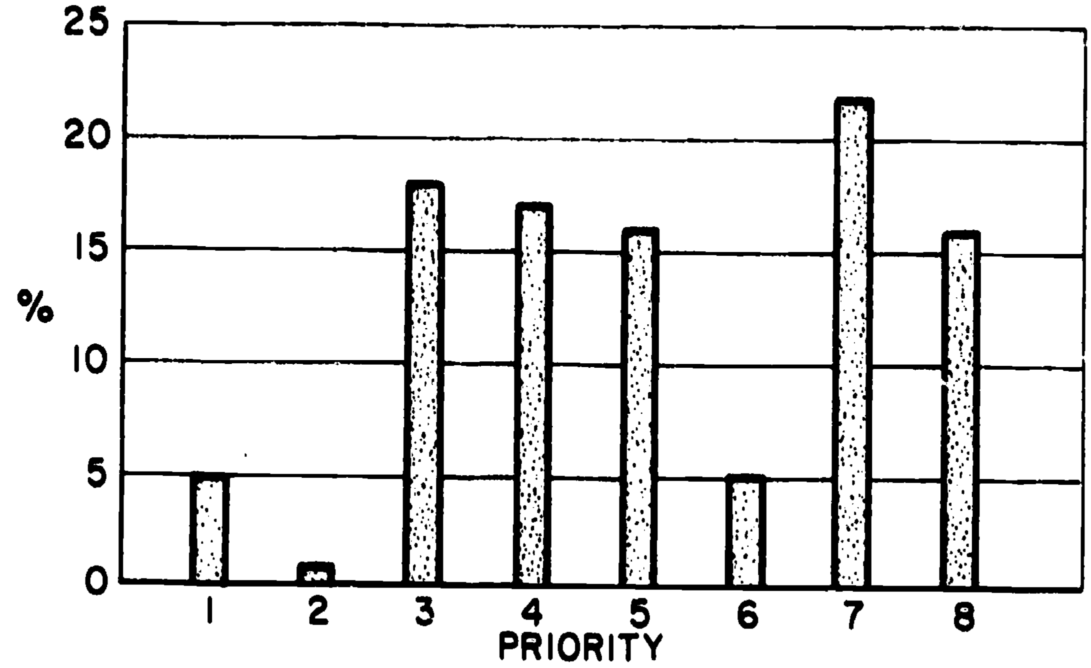


(a) HYDROMECHANICS

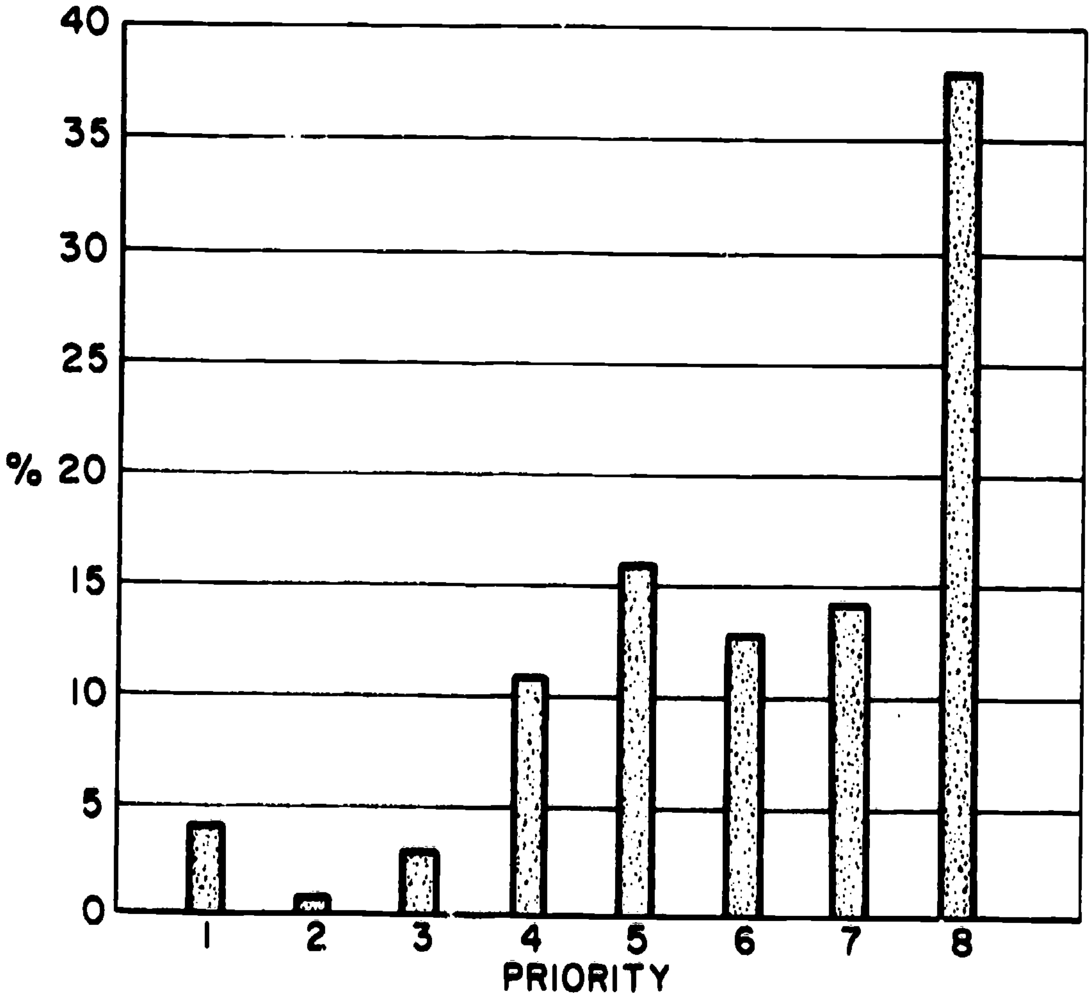


(b) WAVE THEORIES

FIG. 15 MASTER'S DEGREE PROGRAM-PRIORITIES IN BASIC MATERIAL



(a) COMPUTER PROGRAMMING



(b) MAN-IN-THE-SEA

FIG. 16 MASTER'S DEGREE PROGRAM-PRIORITIES IN BASIC MATERIAL

The curriculum should include the following applications: (Also summarized in Table XII)

(1) Beach processes

(2) Wave uprush

(3) Wave Forces

(4) Coastal structures

(5) Foundations

(6) Sedimentation

(7) Corrosion

(8) Floating Structures

(9) Undersea Structures

(10) Pipelines

(11) Dredging

(12) Salvage

(13) Tool Development

(14) Mineral recovery

(15) Measurements

(16) Communications

(17) Transportation

(18) Offshore Harbors

(19) Mariculture

(20) Development of coastal zone

(21) Harbor engineering

(22) Ecological effects

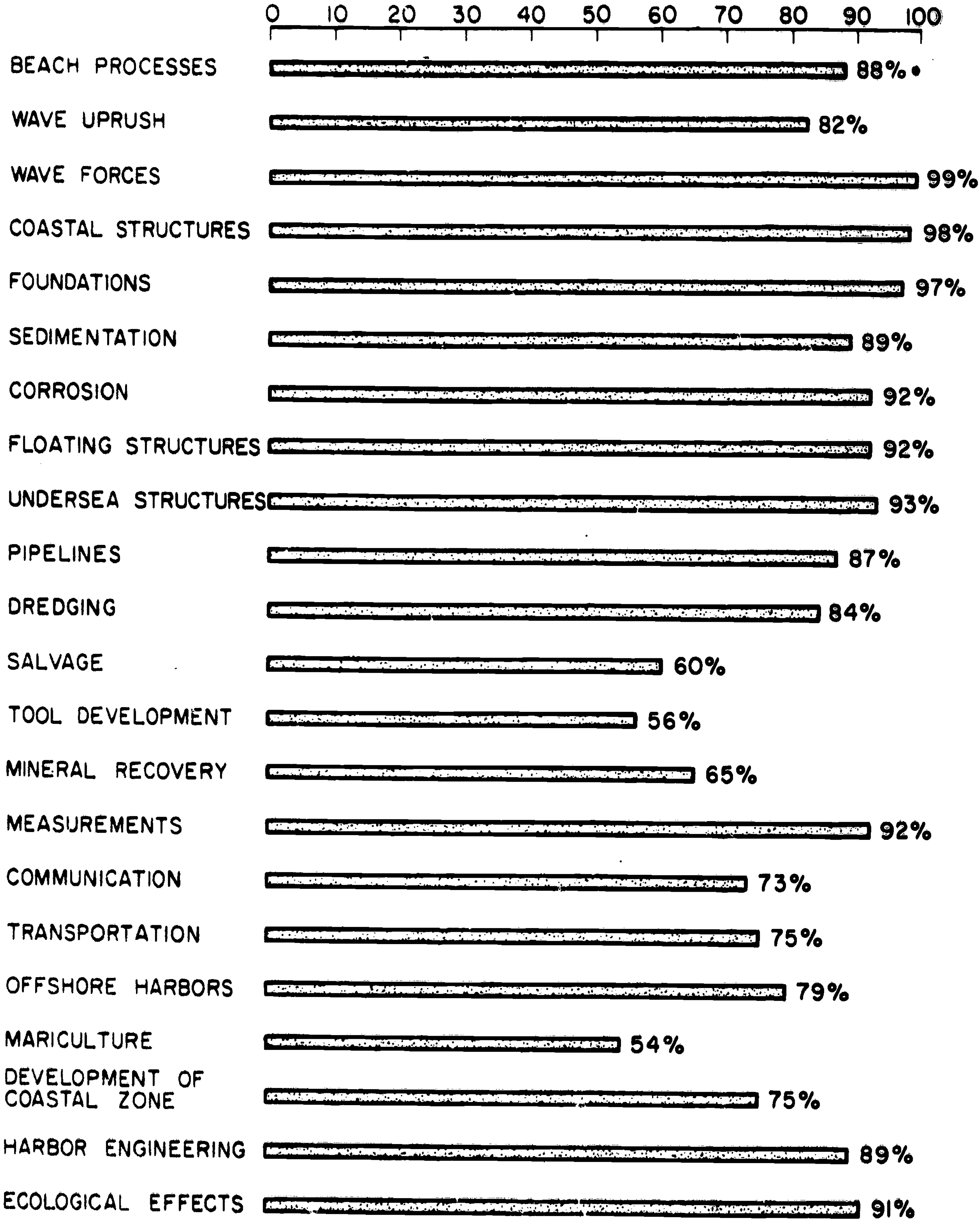
The above information is tabulated (Table XII) and also shown graphically (Figure 17) in the following pages. A priority list of the applications is shown next (Table XIII).

APPLICATIONS

BEACH PROCESSES	(88% AGREED)
WAVE UPRUSH	(82%)
WAVE FORCES	(99%)
COASTAL STRUCTURES	(98%)
FOUNDATIONS	(97%)
SEDIMENTATION	(89%)
CORROSION	(92%)
FLOATING STRUCTURES	(92%)
UNDERSEA STRUCTURES	(93%)
PIPELINES	(87%)
DREDGING	(84%)
SALVAGE	(60%)
TOOL DEVELOPMENT	(56%)
MINERAL RECOVERY	(65%)
MEASUREMENTS	(92%)
COMMUNICATIONS	(73%)
TRANSPORTATION	(73%)
OFFSHORE HARBORS	(79%)
MARICULTURE	(54%)
DEVELOPMENT OF COASTAL ZONE	(75%)
HARBOR ENGINEERING	(89%)
ECOLOGICAL EFFECTS	(9 %)

TABLE XII

APPLICATIONS: M.S. CURRICULUM



• 88 PERCENT OF RESPONDENTS GAVE AFFIRMATIVE ANSWERS

FIG. 17 MASTER'S DEGREE CURRICULUM - APPLICATIONS

APPLICATIONS

PRIORITIES

(1) WAVE FORCES
(2) BEACH PROCESSES
(3) COASTAL STRUCTURES
(4) FOUNDATIONS
(5) UNDERSEA STRUCTURES
(6) FLOATING STRUCTURES
(7) WAVE UPRUSH
(8) PIPELINES
(9) SEDIMENTATION
(10) CORROSION
(11) ECOLOGICAL EFFECTS
(12) DREDGING
(13) MEASUREMENTS
(14) COMMUNICATIONS
(15) MINERAL RECOVERY
(16) OFFSHORE HARBORS
(17) DEVELOPMENTOFCOASTAL ZONE
(18) HARBOR ENGINEERING
(19) TRANSPORTATION
(20) SALVAGE
(21) TOOL DEVELOPMENT
(22) MARICULTURE

TABLE XIII

PRIORITIES IN APPLICATIONS: M.S. CURRICULUM

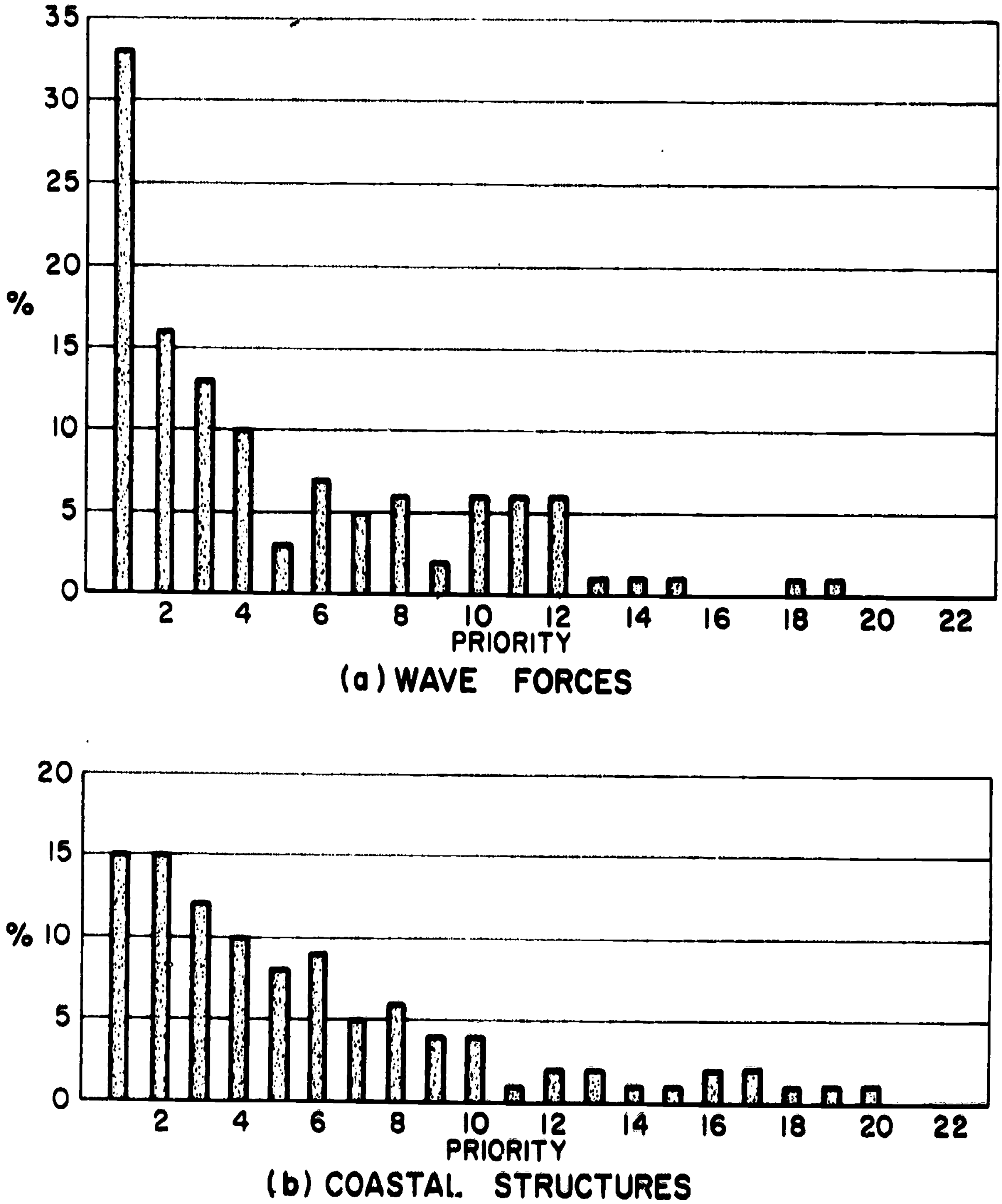


FIG. 18 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

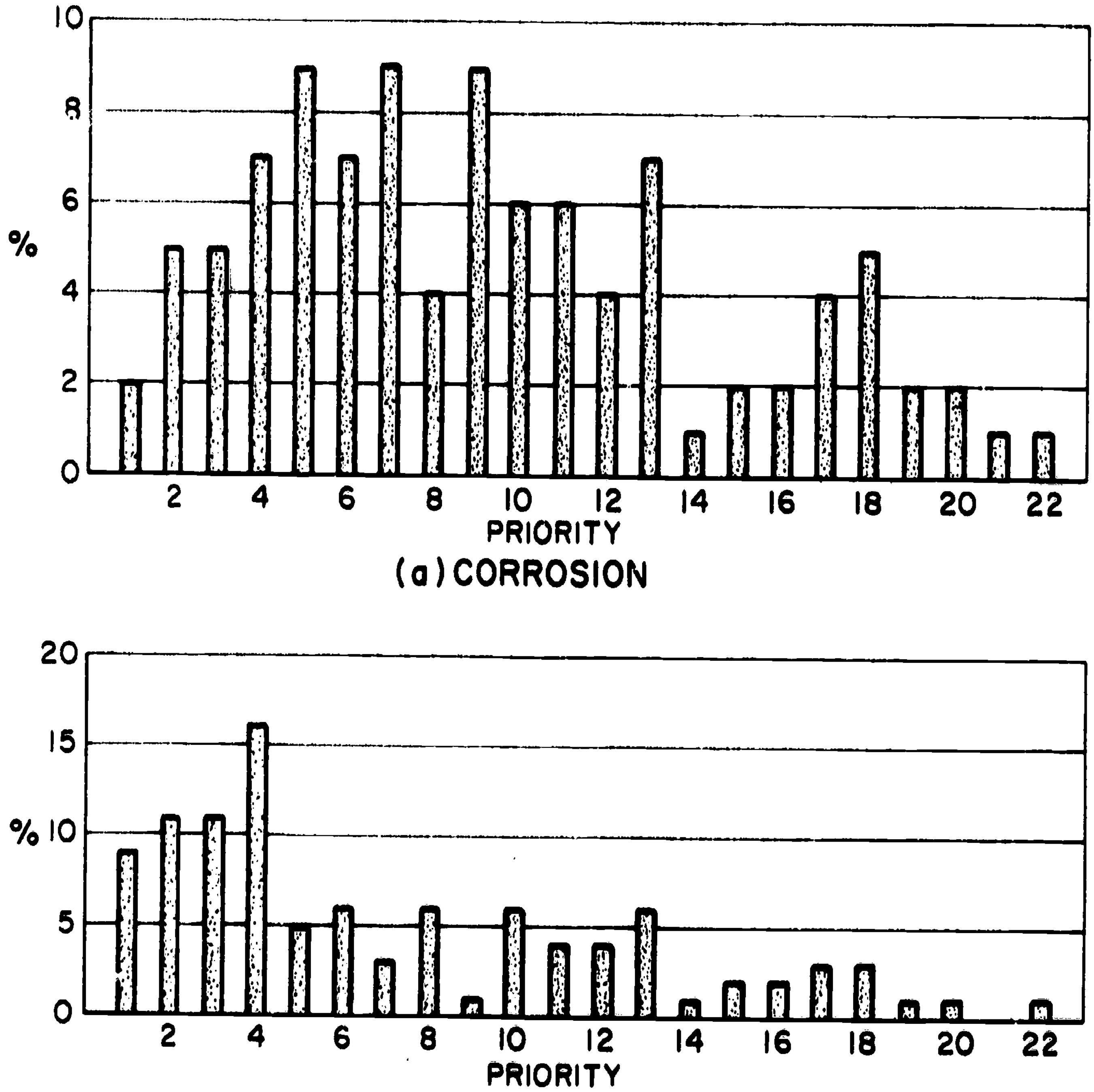
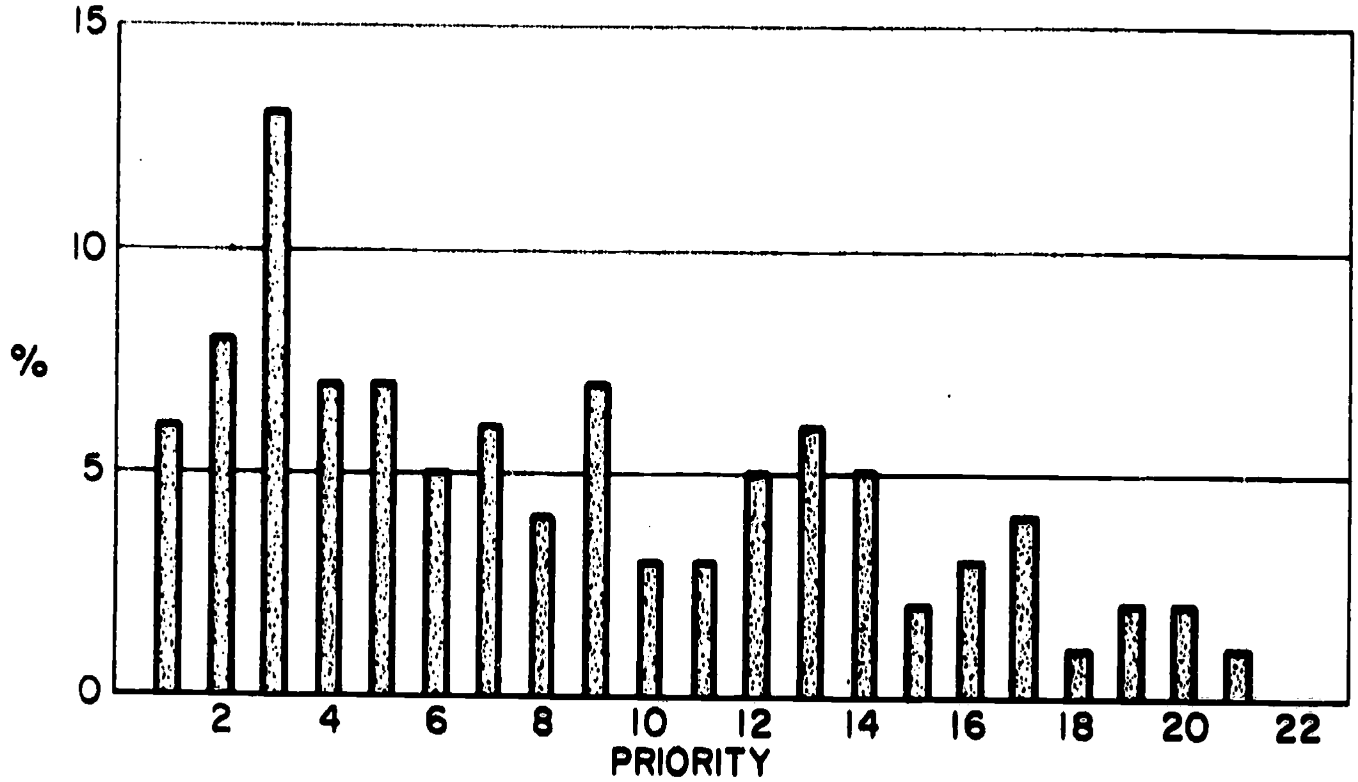
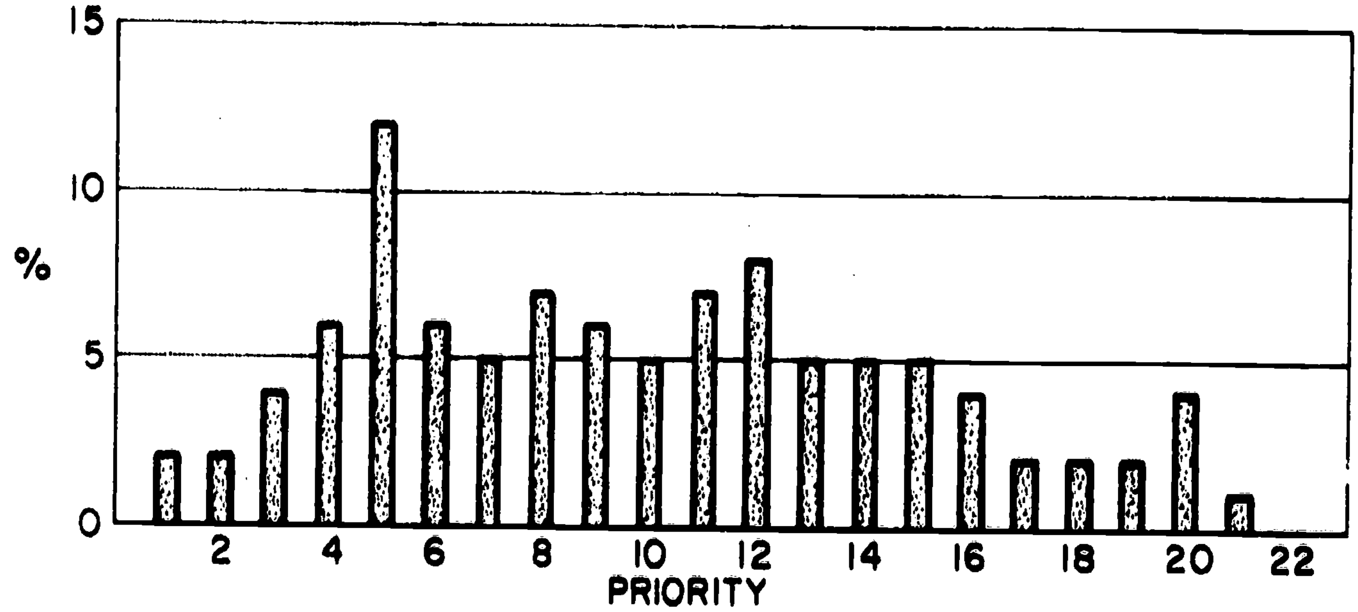


FIG. 19 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS



(a) UNDERSEA STRUCTURES



(b) PIPELINES

FIG. 20 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

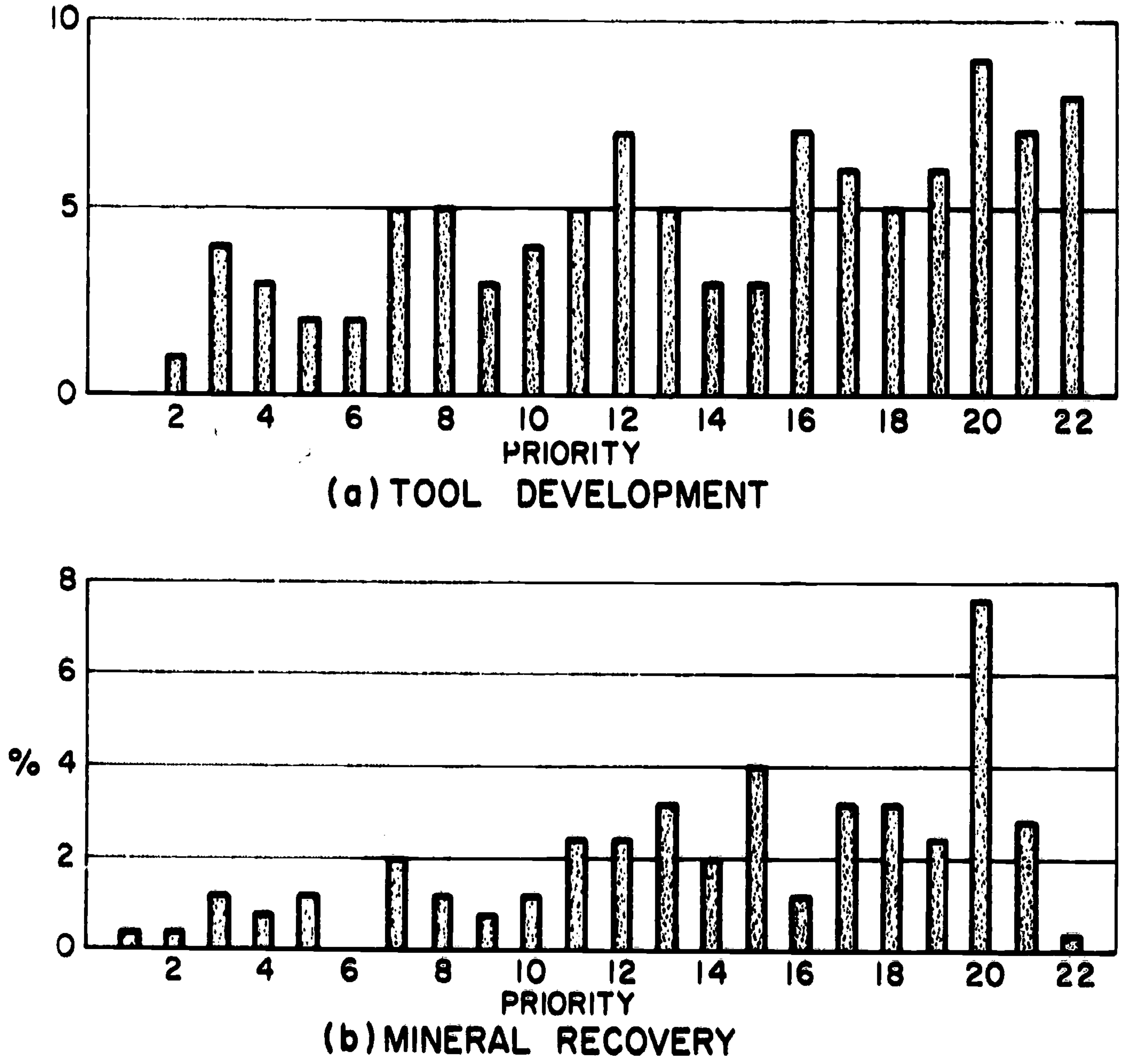


FIG. 21 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

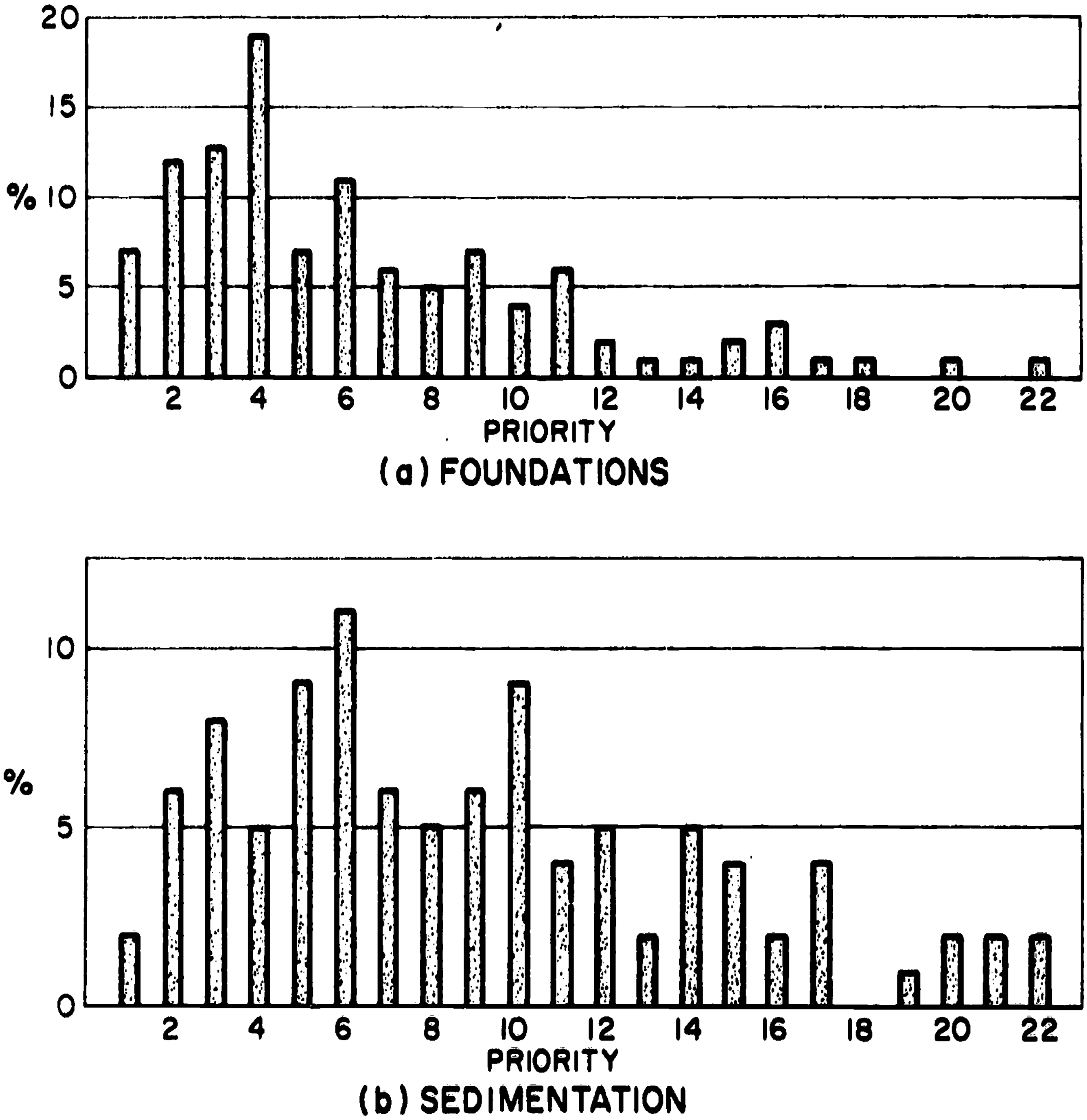


FIG. 22 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

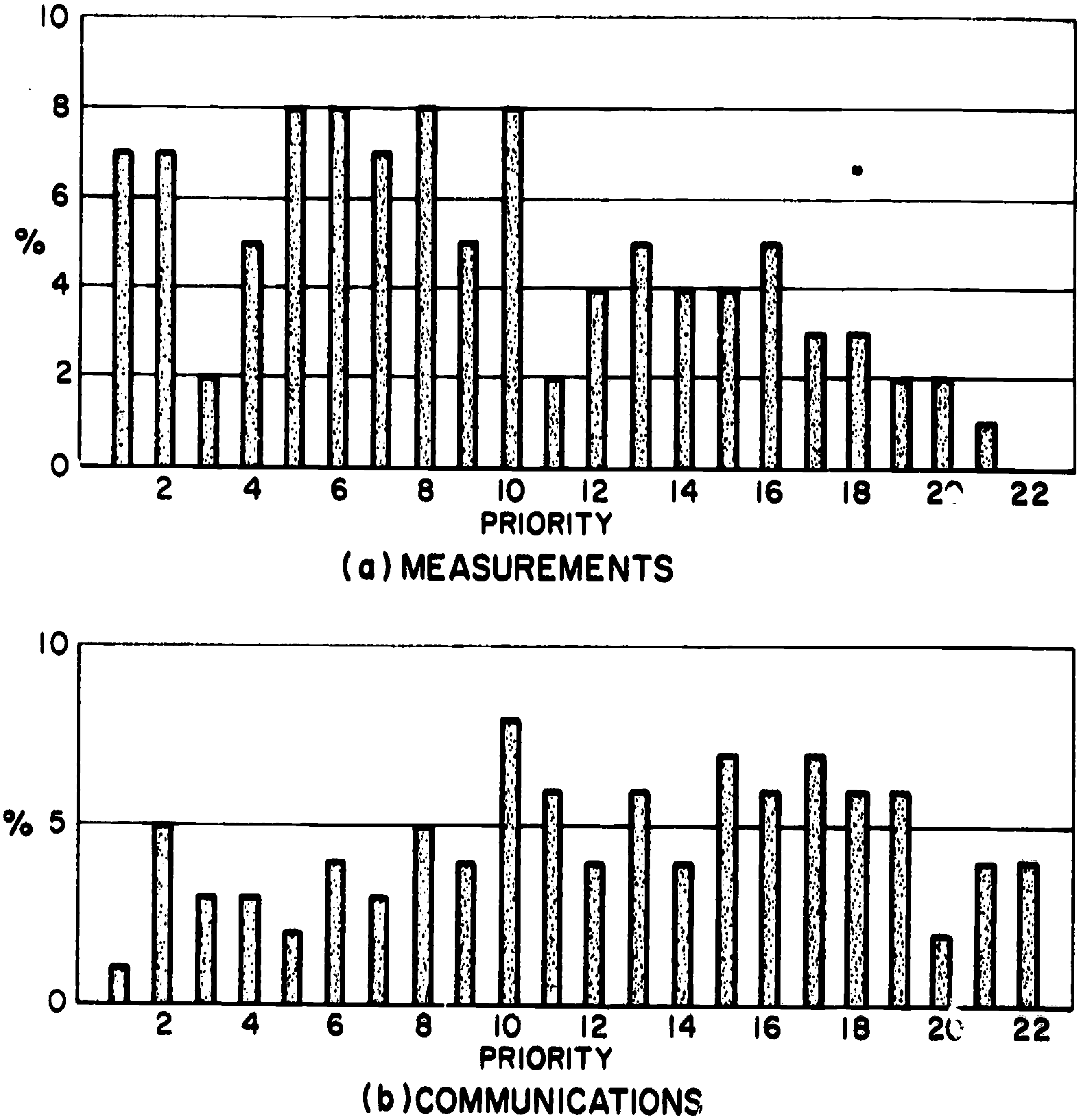
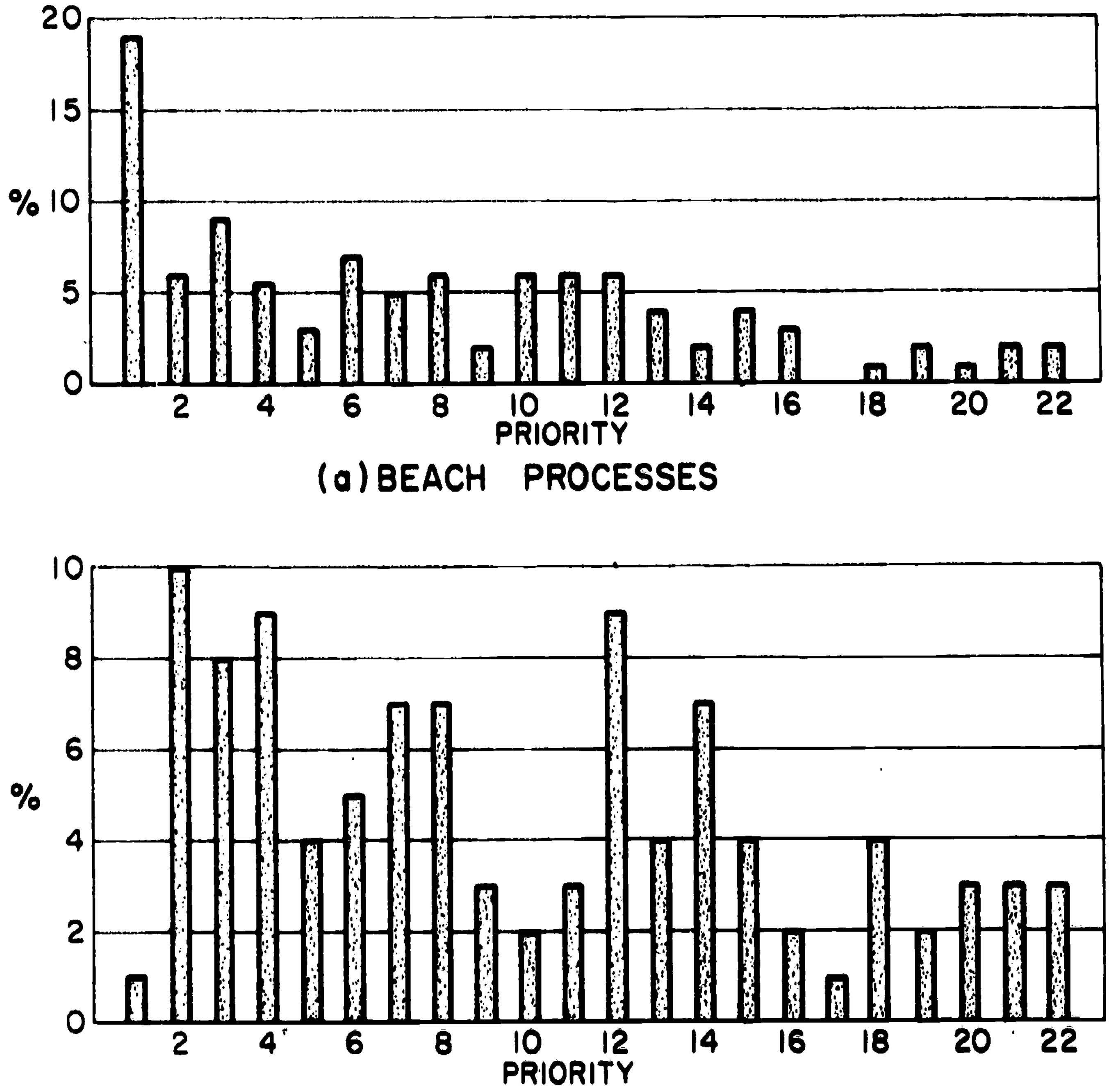


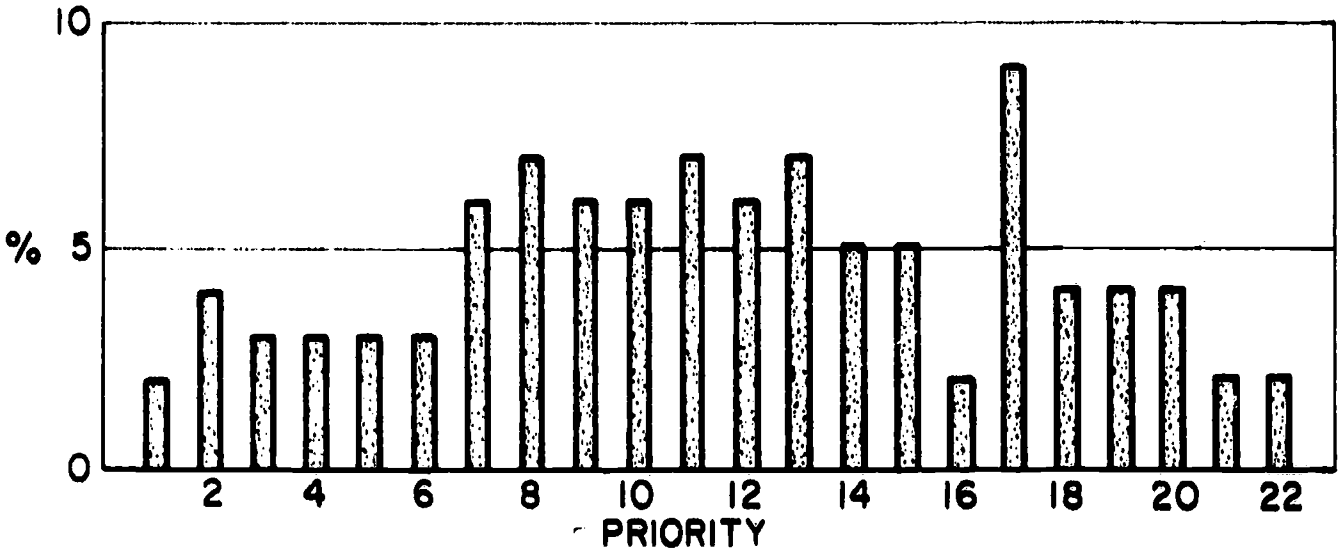
FIG. 23 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS



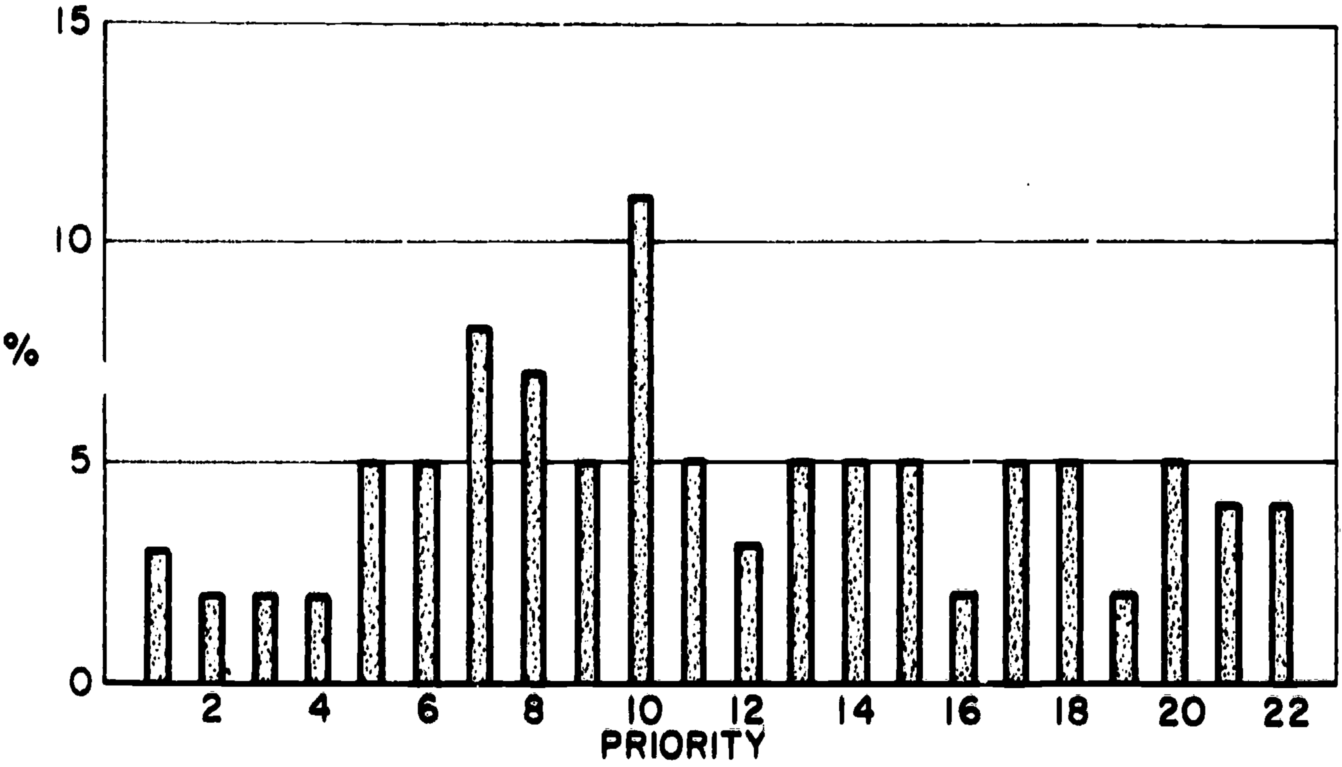
(a) BEACH PROCESSES

(b) WAVE UPRUSH

FIG. 24 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS



(a) HARBOR ENGINEERING



(b) ECOLOGICAL EFFECTS

FIG. 25 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

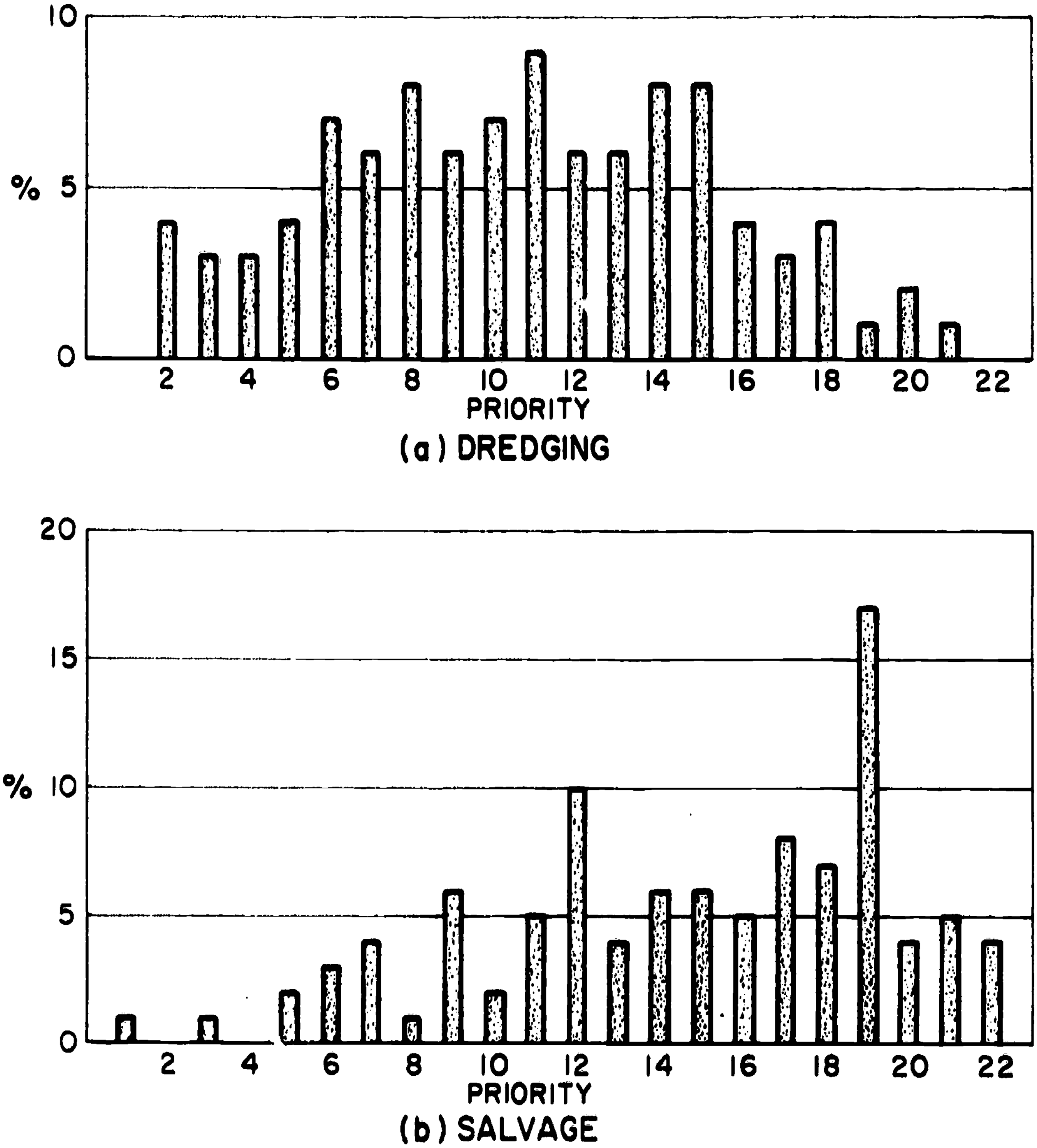


FIG. 26 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

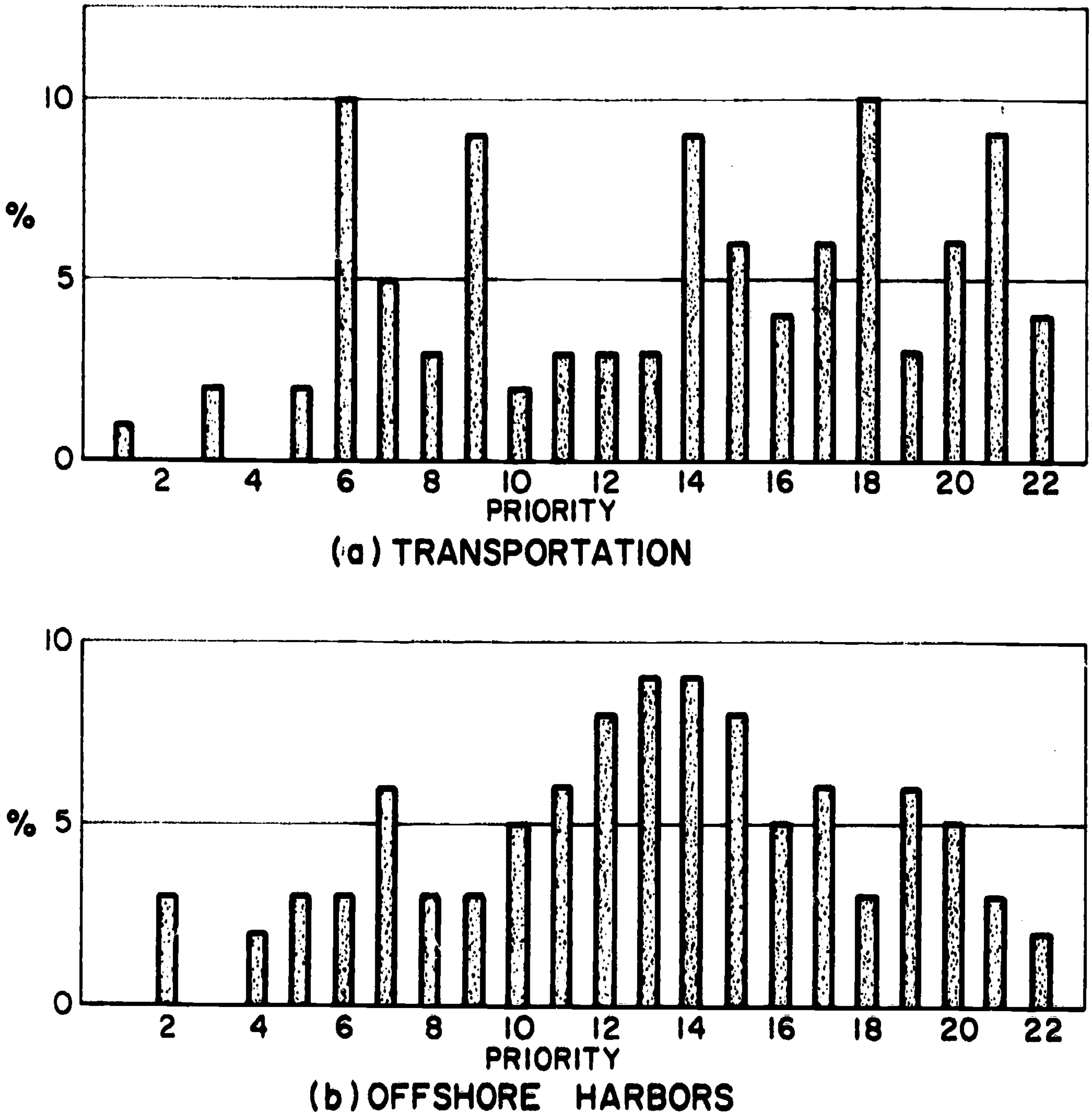


FIG. 27 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

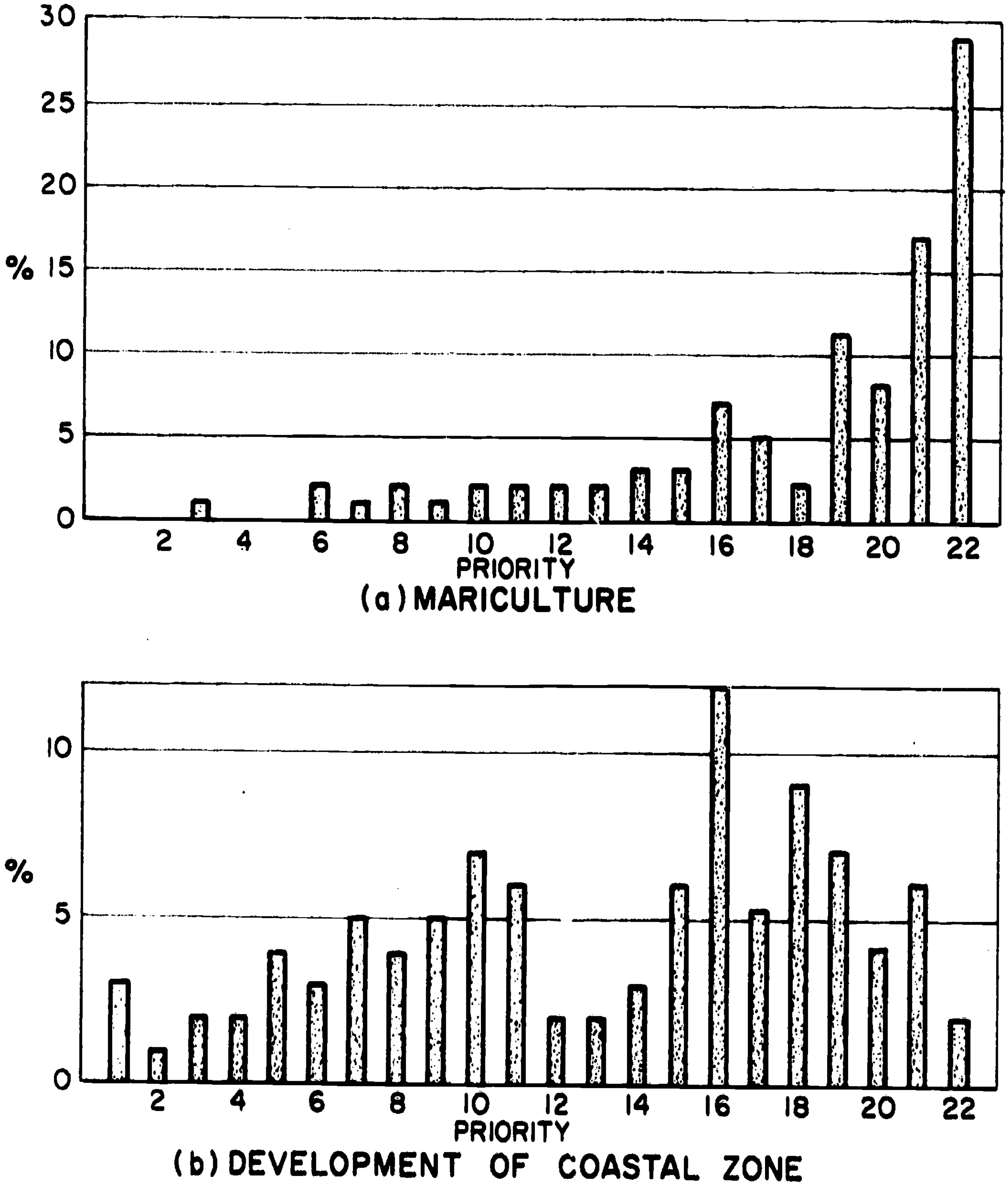


FIG. 28 MASTER'S DEGREE PROGRAM-PRIORITIES IN APPLICATIONS

Since it would be impossible to cover all of the basic materials and applications in depth in any master of science program, a cut-off line would have to be drawn. The line would probably be drawn somewhere after No. 4 (Geological Oceanography) in basic materials and after No. 9 (Sedimentation) in applications. Any subject matter with lower priorities would have to be taken as electives. Since no single university could provide strong courses in all of these topics, a student would select courses from whatever is available in any given university.

As in the section concerning the undergraduate curriculum, the questions on the Master's Degree program also included a space for any comments that anyone might wish to make. The following are the comments received.

COMMENTS RECEIVED
IN MAIL QUESTIONNAIRE

Question 12

Please give any general comments regarding the master's degree curriculum which may help in evaluating the industrial viewpoint.

Program classified seems too specific, not general enough. We need people with good fundamental training, not narrow specialists. I cannot be too concerned about whether you include "deep ocean" engineering of "offshore" engineering. A person with good basic background should be equally at home in beach processes or deep ocean floating equipment. Why differentiate?

Include seminars where engineers in the field may present relevant papers expressing problems which still need solutions, application of conventional engineering to ocean environment with comments as to confidence and risk factors, and have these engineers available to comment on student presentations.

The M.S. curriculum should be flexible enough to form several optional M.S. programs to fit the individual interests of the student.

Out of the above a B.S. engineer should have at least one marketable skill i.e. structural, soils, etc. so he can pay his way while learning this overall problem offshore.

More field practice, say another six months.

Ocean Engineering tends to encompass broad areas and interdisciplines. a, b, d, f, t seem to be variations of a single subject. m is important for background. d, c, e, i, r and w are also variations of one subject. Meterology - basics would be a good addition, so that c would be better understood.

It is impossible to rate the 22 fields in order of importance. It depends to a great extent on an individual interest. There are needs for all fields. Basic education should stress what needs to be understood and why (in the contemporary analysis) and provide the tools for further investigation. As scientific training systems analysis and/or critical path training is mandatory.

Graduates should have knowledge of wind and wave forces and be able to predict the statical and dynamic response of offshore structures subjected to such forces.

Methods and economic considerations in extracting minerals from sea floor.

Consider options in emphasis - e.g. offshore oil (large need), military (large need), food and drugs (small need), civil applications (small need which will grow).

Same comments as 9e apply. In looking at a prospective ocean engineer, would look for specialization in field he is to be used. However, he should have a broad basic background.

As I see it, the need is for as wide a training as is possible in the time available with emphasis on the fundamental knowledge which will allow rapid development into specific fields, if necessary.

Advanced mathematics and advanced (Fluid Mechanics, Hydraulics, Hydrology, Ocean Engineering, Item 11) plus deep research on sedimentation and diffusion in stratified flow with special concentration on salinity and thermal pollution.

The master's degree efforts should involve more the practical experience being academically reviewed and treated and not the academic experience alone. The objective should not be to produce lifetime students but to provide an effectively producing man with the tools and research capability to allow him to make himself more effective.

Design-oriented.

The M.S. should be oriented toward planning, economics, and feasibility of projects in the coastal zone and continental shelf.

Curriculum should include some brief coverage of speciality items such as salvage, tool design, dredging, etc., but should concentrate major efforts on basics of chemical, physical, geological, hydrodynamics, etc.

Good fundamental engineering and ocean environment background necessary to produce adaptable competent ocean engineers.

Re: question 11: My view is that a student with say a B.S. in C.E., interested in ocean structures, may wish to take some study in that specific area, but also would want to take more work in structural mechanics or related areas. He would be oriented by the basic ocean courses such as described in question 10.

We would like a graduate at the M.S. level to have a general background of various civil engineering-oriented marine subjects.

Knowledge of the basic tools and awareness in their usage.

Working knowledge of physical and technological aspects of ocean oriented sciences should be required prior to Master's program. Most advanced degrees today are merely upgrading students not producing practical engineers and scientists, hence complete disregard for budget and practicality. Some knowledge of all of these items would be of use but could not be covered in depth. Priority would depend on direction of endeavor intended.

Generally, industry favors graduates who have a breadth of knowledge and shies away from extreme specialization (except for a limited number of specialized research positions). Industry usually prefers to give the detailed knowledge during the employee's work. As always, practicality (both in theory and application) is absolutely essential.

It looks like the primary employers, other than research laboratories and schools, for ocean engineers are (1) weapons designers, (2) U.S. Army Corps of Engineers, and (3) Oil companies (and their consultants). Thus, there might be three specialized branches and programs offered with electrical engineering, marine biology, and oceanography, since they primarily involve those disciplines.

I think basics should be stressed at B.S. level of specialization reserved for M.S. and Ph.D.

Master's degree program should be based on assumption that candidate has had good engineering fundamentals background - program should thus be geared to detail all phases of the marine environment and engineering applications.

The Master's degree should be used to include details and advanced knowledge after the basic sciences and engineering fundamentals are presented on the undergraduate level. Several subdivisions may be desirable (i.e. Deep Oceans, Continental Shelf, Near Coastal, etc.).

On a graduate level, I would think that some of the above courses could be combined i.e. after having strength of materials and associated courses in undergraduate school, the structures courses could be covered in one course.

Obviously not all of the above subjects can be covered so it will be necessary to group them and then allow certain specialized electives.

Priorities given only for those students primarily interested in coastal engineering, strong emphasis should also be placed on advanced mathematics including numerical analysis and probability theory.

Would encourage continuation of broad-based curriculum; major need is for "generalists" as opposed to "specialists" in the ocean environment.

I would expect that about 1/2 the study would be in advanced aspects of some basic disciplines, i.e., applied mechanics for structural people, or applied hydrodynamics for submersible design people, or signal processing for underseas communications people.

Seldom does industry hire a new technologist for knowledge - rather for his potential, therefore, I would hardly want a man complete with the prejudices of his tutor, the less specific his background the better.

As before, the legal aspect as to ownership, along with the defense aspect of exploiting the offshore environment should be studied.

An ocean engineering graduate should be able to design and build stationary structures located in ocean and on ocean shores, while an ocean science graduate should be able to understand and manage the ocean environment. (A naval architect designs moving ocean vehicles).

I personally, in my design work for my company, have been primarily concerned about: Scour at bridge pier and through tidal reaches (2nd Hampton Roads Bridge-Tunnel, Norfolk Virginia, 63rd Street sunken tube NYC), rip rap slope protection (2nd Hamption Roads Bridge-Tunnel), and wave forces on bridge piers and decks (2nd Hampton Roads Bridge-Tunnel).

The concept of an oceanographic "technician" should be given "official" status with honors in specialized facets (i.e. - man-in-sea-aquaculture, etc).

The items listed in paragraph 11 above combine readily into general categories indicated by the brackets. (planning, operations, engineering or structures, physical processes.) The categories listed would appear to be the areas for master's degree application.

Since the candidates will not be broadly based in the marine field--you should concentrate on producing specialists not generalists at the M.S. level.

Include strong courses in Physical Oceanography.

Ship engineering and mathematics--valuable electives.

Looks like you need branches for concentration of study rather than superficial treatment of everything.

Suggest that candidates for Master's degree be given every opportunity and encouragement to enhance their knowledge of the beach processes along the Texas coast.

It is necessary to have more contact with electronic engineering to make better instrumentation for the data in the field.

Specialization in at least two ocean-related fields should be required.

Pollution control (oil spills, dispersion of pollutants in estuaries, etc.) should be included.

The master's degree candidate should be encouraged to undertake original work in the form of a thesis, in addition to course work.

Actual field operations--equipping, measuring, etc. are the provinces of ocean engineering and physical scientists--planning and analysis by ecologists (environmentalists). Again--management is missing--a key factor.

Basic research studies on problems of--Wave Forces, Structure Oscillations and Mooring requires a strong background in Wave Theories, Wave Forces and Hydromechanics. Emphasis should be placed on the equation of motion:

$$m'x + cx + kx = p_{sin}\, \sigma t + q_{cos}\, \sigma t$$

m' = total virtual mass
c = damping constant
k = spring modulus
x = displacement
p = sine component of the total wave inertia force
q = cosine component of the total wave inertia force

I do not believe that Civil Engineering curriculum should compete with that of Marine Science, Biology, Geology, etc. However, I do believe that the ecological effects of dredging operation and coastal structures should be understood by the Civil Engineer at least to the point that he can communicate with these other disciplines.

There seems to be a complete void in two major areas. (1) Life support and (2) Salvage. What is really needed are not text book engineers but practical working engineers on an industrial level. I think you are overlooking an important phase of diver education.

In the master's program I would expect more specialization. My overall feeling, however, is that basic fundamentals plus the ability to communicate are still the most important in any program.

I visualize this curriculum as appropriate for holder of B.S. or B. Engineering degree who, after perhaps several years effort in a marine or related field, has acquired some interest (specific - general) which he wishes to pursue with the freedom for study or investigation which does not normally occur to the occupant of a remunerative position in today's American Industry. I am aware of at least some of the financial problems this schedule would generate, I do not limit these remarks to "ocean engineering."

Our research and development program cuts across the lines of all above applications.

A good background in the basic physical marine environment is necessary in order to evaluate the forces acting on marine structures. Ocean waves, physical oceanography, hydrodynamics are important areas.

Master's degree program should be confined to one or two topics listed above as specialization.

Industry will move further and further offshore, and also pay continuously more attention to ecological effects of mishaps.

Emphasis should be on giving the student greater depth in applied as well as the theoretical engineering in his specialty; i.e., dynamics of structures for structural engineers, as affected by the ocean environment.

I am not sure a master's degree is needed.

Should include discussions of oceanographic measurements, oceanographic operations, materials selection, corrosion and biodegredation, wave theories and wave forces (applications), review of physical and geological oceanography, ecological considerations and sea floor engineering.

I estimate that only about 20% of those who complete a master's degree curriculum will ever be involved in truly industrial ocean activity. The other 80% will have to be absorbed in the academic effort.

Our interest would be in the understanding of the physical environment and forces and a concept of their effects on structures The basics should have been covered in undergraduate school. Specific expertise should be developed within a specific employment.

M.S. should build on basic engineering foundation which stresses fundamentals and not design details. Technology is advancing too fast for "Handbook" engineers. Interelationship of disciplines (coordination) needed.

A student entering a master's degree program should first think about the area in which he wants to work--teaching?--research?--or professional practice, i.e. applied engineering?--then select his curriculum accordingly.

Your approach is too broad. The industries need specific knowledge in all areas--no man short of a professional student can acquire all of the above in a reasonable B.S. and M.S. curriculum.

What we need are engineers with a good fundamental training and who can then apply this background in a practical way. The importance of technical writing must be stressed. Courses in business management and engineering economics should also be included.

Make certain that teaching staff has enough practical experience to help the students.

I feel that construction will have limited needs for people with a master's in ocean engineering. There will probably be considerable need for these people in consulting firms.

Basic knowledge of science is needed. Mass application information is learned later. Acoustics should be available course.

Allow special credit for anyone obtaining one year practical experience in ocean engineering trade prior to starting master's curriculum.

Two years minimum of course work. The time devoted to one particular subject should be limited so that the master's degree is more of an extension of the undergraduate curriculum.

Consider long term effects under real (dynamic) ocean conditions.

I see no basis of assigning priorities under 11 without knowing the individuals future work. I feel that a thorough grounding in Hydromechanics is essential; computer programming is desirable. A firm foundation in mathematics and physics is highly desirable. All of these are more important than the listed

applications. I prefer to recruit a man with a good background and I will provide more specialized application on the job at all levels.

I am not sure a master's degree is needed.

Emphasis should be placed on the identification and understanding of the subtleties associated with the application of scientific principles and knowledge to the economical solution of marine technology problems.

Should contain more practical field work.

What do I look for in a man? First he must be well grounded in the fundamentals of physics, mathematics, analysis, computer applications and usage. By way of illustration:

Physics
- Hydrodynamics
- Acoustics
- Thermodynamics (including statistic thermodynamics)
- Optics
- Electricity and Magnetics
- Illumination--Visibility--Light

Mathematics
- Functions
- Differential Equations
- Complex Variables
- Problem Solving
- Transforms
- Matrix Algebra
- Probability
- Statistics
- Stochastic Processes
- Operational Mathematics
- Numerical Analysis
- Operations Research

Communications
- Information Theory
- Noise
- Modulation
- Transmission
- Synthesis, Network and Systems
- Systems Analysis
- Sampled Data
- Statistical Communication Theory
- Measurements
- Acoustics
- Data Processing

Mechanics
- Materials--Metallurgy--Plastics
- Strength
- Application
- Processing
- Degradation
- Statics and Kinematics
- Structures and Machines

Computers
- Applications
- Input--Output
- Logical Design
- Programming
- Data Reduction
- On Line Applications

Economics
- Value
- Capital--Conservation and Generation
- Trade-Offs

With a foundation in the majority of these subjects, I can put him to work, productively, if he has the second prerequisite, which is: how-to-think!

Ocean Engineering is merely the application of mathematical and physical principles to solving problems pertaining to ocean applications. (This observation has evolved during the last 17 years that I have been working in the general area of Ocean Systems). Consequently, the trade-school approach will only short-change the student in the long run.

For example 11(n) Mineral Recovery--how could a course be taught in this subject, when the techniques are still under investigation by Hughes, Global Marine, Deep Sea Ventures, and a couple of others. Hughes is ready to go with an investment in the vicinity of $100M if and when their studies show that the techniques are going to be econimically feasible.

The technology changes very rapidly today--the fundamentals always remain the same. My one comment would be--teach your students:

1. The fundamentals;
2. How to apply the fundamentals, to the real world;
3. How to think;
4. The techniques how to solve problems.

CONCLUSIONS

1. Many established disciplines are working in the ocean engineering field. The engineering disciplines involved are civil, mechanical, ocean, structural engineering, naval architecture, etc.

2. Many involved in ocean engineering activities hold advanced degrees.

3. Those working in the ocean engineering field are principally involved in feasibility studies, design and construction; and in the following sub-fields: ocean structures, coastal engineering, ocean foundations, ocean pipelines, and estuary engineering.

4. The majority of respondents favor offering ocean engineering degrees on both undergraduate and graduate levels.

5. The B.S. curriculum should include basic sciences, core material, applied sciences and humanities.

6. The M.S. curriculum should include basic material including physical oceanography, hydromechanics, wave theories, geological oceanography, etc. The applications part of the program should include wave forces, beach processes, coastal structures, foundations, undersea and floating structures, wave uprush, pipelines, etc.

REFERENCES

1. Herbich, J.B. "Ocean Engineering Programs", Engineering Education, February, 1970.

APPENDICES

APPENDIX I

LETTER SENT TO RECEIPIENTS OF QUESTIONNAIRES

TEXAS A&M UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING
COLLEGE STATION TEXAS 77843

COASTAL AND OCEAN ENGINEERING DIVISION
HYDRAULIC ENGINEERING AND FLUID MECHANICS DIVISION

April 26, 1971

Dear Recipient of this Questionnaire:

In developing and up-dating *ocean engineering curricula* it is important that we are aware of the *industrial viewpoint* regarding our product: the ocean engineers. After all, you employ our graduates and we certainly wish to produce engineers which will be best trained for your needs.

This brief survey is conducted to determine *your viewpoint* regarding the subject matter which should be included in an ocean engineering educational program. Since the success of this study depends to a large extent on the complete responses received we urge you to complete the enclosed questionnaire and *return it to me within 48 to 72 hours after receipt of this letter*. The questionnaire is designed to require *less than 15 minutes to complete*.

Your cooperation is very much appreciated.

Yours sincerely,

John B. Herbich

John B. Herbich, Ph.D., P.E.
Professor and Head
Coastal and Ocean Engineering Division

JBH:bg

QUESTIONNAIRE

Number ______

Please return within 48 hours in enclosed envelope to Dr. J. B. Herbich, Coastal and Ocean Engineering Division, Texas A&M University, College Station, Texas 77843.

OCEAN ENGINEERING CURRICULUM - AN INDUSTRIAL VIEWPOINT

☐ I am not involved in ocean engineering activities. I am returning this questionnaire unanswered.

☐ I am involved in some aspect of ocean engineering activities and I am answering the survey questions.

Note: OCEAN ENGINEERING is a broad interdisciplinary field and may be considered to cover all engineering endeavors in the ocean environment.

BACKGROUND AND EMPLOYMENT PROFILE

Please Mark in Appropriate Places

1. Highest degree attained: B.S. ☐, M.S. ☐, Ph.D. ☐.
2. Major field of study (at highest educational level) ______.
3. Total Number of employees in your organization (approximate) ______.
4. Number of employees working in ocean engineering field (approximate) ______.
5. I am working in the sub-field of (multiple answers acceptable), physical oceanography ☐, coastal engineering ☐, estuary engineering ☐, ocean structures ☐, ocean foundations ☐, ocean pipelines ☐, ocean communication ☐, ocean transportation ☐, ocean surveys ☐, submersibles ☐, dredging ☐, other ☐. Specify ______.
6. Product of your work: conceptual or feasibility studies ☐, design ☐, construction ☐, service ☐, other ☐. Specify ______.

TRAINING IN OCEAN ENGINEERING

Please Mark in Appropriate Places

7. Ocean engineering should be taught on the undergraduate level ☐, should be taught only on the graduate level ☐, should be taught on both levels ☐.

Please Mark the Appropriate Answers

8. Curriculum should be comparable to other engineering degrees which would consist of basic sciences, applied sciences and humanities; Yes ☐ No ☐.

9. The curriculum should include

   (a) Basic sciences Yes ☐ No ☐

   (b) Core material including information on

Ocean Environment	Yes ☐	No ☐
Material Behavior	Yes ☐	No ☐
Human Factors	Yes ☐	No ☐
Communications	Yes ☐	No ☐

   (c) Applied sciences including engineering in, or of

Shore and Estuaries	Yes ☐	No ☐
Offshore	Yes ☐	No ☐
Deep Ocean	Yes ☐	No ☐
Measurements	Yes ☐	No ☐
Aquaculture	Yes ☐	No ☐
Ecological Effects	Yes ☐	No ☐

   (d) Since in a four-year curriculum it would be impossible to cover all the applied topics, what priority would you assign to these topics?

Assign priority numbers from 1 to 9 below

Shore ☐, estuaries ☐, offshore ☐, deep ocean ☐, measurements ☐, communications ☐, aquaculture ☐, ecology ☐, other ☐,

Specify ______________________________

   (e) *Please give any general comments regarding the undergraduate curriculum which may help us in evaluating the industrial viewpoint.* ______________

____

____

____

10. Curriculum should include the following basic material:

(a) Physical oceanography Yes ☐ No ☐ Priority ☐

(b) Geological oceanography Yes ☐ No ☐ Priority ☐

(c) Chemical oceanography Yes ☐ No ☐ Priority ☐

(d) Biological oceanography Yes ☐ No ☐ Priority ☐

(e) Hydromechanics Yes ☐ No ☐ Priority ☐

(f) Wave theories Yes ☐ No ☐ Priority ☐

(g) Computer programming Yes ☐ No ☐ Priority ☐

(h) Man-in-the-sea Yes ☐ No ☐ Priority ☐

Please Assign Priority Numbers from 1 to 8 in the Third Box Above

11. The curriculum should include the following applications:

(a) Beach processes Yes ☐ No ☐ Priority ☐

(b) Wave uprush Yes ☐ No ☐ Priority ☐

(c) Wave forces Yes ☐ No ☐ Priority ☐

(d) Coastal structures Yes ☐ No ☐ Priority ☐

(e) Foundations Yes ☐ No ☐ Priority ☐

(f) Sedimentation Yes ☐ No ☐ Priority ☐

(g) Corrosion Yes ☐ No ☐ Priority ☐

(h) Floating structures Yes ☐ No ☐ Priority ☐

(i) Undersea structures Yes ☐ No ☐ Priority ☐

(j) Pipelines Yes ☐ No ☐ Priority ☐

(k) Dredging Yes ☐ No ☐ Priority ☐

(l) Salvage Yes ☐ No ☐ Priority ☐

(m) Tool development Yes ☐ No ☐ Priority ☐

(n) Mineral recovery Yes ☐ No ☐ Priority ☐

(o) Measurements Yes ☐ No ☐ Priority ☐

(p) Communications Yes ☐ No ☐ Priority ☐

(q) Transportation Yes [ ] No [ ] Priority [ ]

(r) Offshore harbors Yes [ ] No [ ] Priority [ ]

(s) Mariculture Yes [ ] No [ ] Priority [ ]

(t) Development of coastal zone Yes [ ] No [ ] Priority [ ]

(u) Harbor engineering Yes [ ] No [ ] Priority [ ]

(v) Ecological effects Yes [ ] No [ ] Priority [ ]

Please assign priority numbers from 1 to 22 in the Third Box Above

12. *Please give any general comments regarding the master's degree curriculum which may help in evaluating the industrial viewpoint.*________________

____

____

____

____

Thank you.

I wish to receive a report summarizing the results of this survey.

Please mark the box if you wish to receive a copy. [ ]

APPENDIX II

(a) Undergraduate Curriculum--Priorities in Applied Science Category

(b) Master's Degree Program--Priorities in Basic Material

(c) Master's Degree Program--Priorities in Applications

(d) Master's Degree Program--Priorities in Applications

(e) Master's Degree Program--Priorities in Applications

(f) Master's Degree Program--Priorities in Applications

SUBJECT MATTER	PRIORITY 1	2	3	4	5	6	7	8	9	TOTAL
SHORE	52(32)*	38(24)	18(11)	17(11)	17(11)	12(7)	3(2)	3(2)	1(.6)	161
ESTUARIES	20(11)	46(26)	33(19)	15(9)	17(10)	14(8)	15(9)	12(7)	2(1)	174
OFFSHORE	72(46)	17(11)	27(17)	19(12)	13(8)	6(4)	3(2)			157
DEEP OCEAN	13(8)	36(23)	16(10)	23(15)	17(11)	28(18)	14(10)	16(10)		163
MEASUREMENTS	9(6)	13(8)	33(21)	34(22)	31(20)	15(10)	12(8)	8(5)	2(1)	157
COMMUNICATIONS	2(1)	3(2)	10(7)	21(14)	12(3)	39(27)	35(24)	16(11)	8(5)	146
AQUACULTURE	2(1)		3(2)	4(3)	10(7)	16(11)	41(28)	64(44)	7(5)	147
ECONOMICS	6(4)	8(5)	26(17)	22(14)	33(22)	16(11)	28(18)	11(7)	2(1)	152
OTHER	1(2)		1(2)	3(5)		1(2)	7(12)	7(12)	39(66)	59

*Numbers in parentheses represent percentages

TABLE II-I

B.S. CURRICULUM--PRIORITIES IN APPLIED SCIENCE CATEGORY

SUBJECT MATTER	PRIORITY 1	2	3	4	5	6	7	8	TOTAL
PHYSICAL OCEANOGRAPHY	74(45%)*	34(20)	30(18)	18(11)	9(5)	1(1)			166
GEOLOGICAL OCEANOGRAPHY	14(9)	30(19)	23(15)	36(22)	29(18)	19(12)	6(4)	1(1)	158
CHEMICAL OCEANOGRAPHY	4(3)	13(9)	15(10)	20(14)	28(19)	32(22)	27(18)	8(5)	147
BIOLOGICAL OCEANOGRAPHY	6(4)	7(5)	12(9)	20(14)	11(8)	35(24)	29(21)	21(15)	141
HYDROMECHANICS	42(26)	42(26)	26(16)	13(8)	19(13)	9(6)	6(4)	2(1)	159
WAVE THEORIES	26(16)	44(26)	34(20)	25(15)	10(6)	17(10)	9(5)	3(2)	168
COMPUTER PROGRAM	8(5)	2(1)	26(18)	25(17)	24(16)	8(5)	31(22)	23(16)	147
MAN-IN-THE-SEA	5(4)	1(1)	4(3)	15(11)	22(16)	18(13)	19(14)	51(38)	135

*Numbers in parentheses represent percentages

TABLE II-II

MASTER'S DEGREE PROGRAM - PRIORITIES IN BASIC MATERIAL

SUBJECT MATTER	PRIORITY 1	2	3	4	5	6	7	8	9	10	11	12
BEACH PROCESSES	24(19)	8(6)	11(9)	8(6)	4(3)	9(7)	6(5)	7(6)	3(2)	8(6)	7(6)	7(6)
WAVE UPRUSH	1(1)	11(10)	9(8)	10(9)	5(4)	5(4)	8(7)	8(7)	3(3)	2(2)	4(3)	10(9)
WAVE FORCES	48(33)	23(16)	19(13)	15(10)	5(3)	5(3)	5(4)	7(5)	4(3)	2(1)	2(1)	6(4)
COASTAL STRUCTURES	21(15)	21(15)	16(12)	12(10)	11(8)	11(8)	7(5)	8(6)	6(4)	6(4)	2(1)	3(2)
FOUNDATIONS	10(7)	17(12)	18(13)	14(19)	10(7)	10(7)	8(6)	7(5)	10(7)	5(4)	8(6)	3(2)
SEDIMENTATION	3(2)	8(6)	10(8)	7(5)	11(9)	11(9)	8(6)	7(5)	8(6)	11(9)	5(4)	6(5)
CORROSION	3(2)	7(5)	7(5)	9(7)	14(9)	14(9)	12(9)	5(4)	13(9)	8(6)	8(6)	5(4)
FLOATING STRUCTURES	11(8)	15(11)	15(11)	22(16)	7(5)	7(5)	4(3)	8(6)	2(1)	8(6)	6(4)	6(4)
UNDERSEA STRUCTURES	8(6)	13(8)	19(13)	11(7)	10(7)	10(7)	8(6)	5(4)	10(7)	4(3)	4(3)	7(5)
PIPELINES	2(2)	3(2)	5(4)	8(6)	15(12)	15(12)	7(5)	10(7)	8(6)	6(5)	10(7)	11(8)
DREDGING	0(0)	5(4)	4(3)	4(3)	6(4)	6(4)	7(6)	11(8)	8(6)	10(7)	12(9)	8(6)

*Numbers in parentheses represent percentages

TABLE II

MASTER'S DEGREE PROGRAM - PRIORITIES IN APPLICATIONS

SUBJECT MATTER	13	14	15	16	PRIORITY 1.	18	19	20	21	22	TOTAL
BEACH PROCESSES	5(4)	3(2)	5(4)	4(3)	0(0)	1(1)	3(2)	1(1)	2(2)	1(2)	127
WAVE UPRUSH	5(4)	8(7)	5(4)	2(2)	1(1)	5(4)	2(2)	3(3)	4(3)	4(3)	115
WAVE FORCES	1(1)	2(1)	2(1)	0(0)	0(0)	1(1)	1(1)	0(0)	0(0)	0(0)	146
COASTAL STRUCTURES	3(2)	2(1)	2(1)	3(2)	3(2)	1(1)	1(1)	1(1)	0(0)	0(0)	140
FOUNDATIONS	1(1)	2(1)	3(2)	4(3)	1(1)	2(1)	0(0)	1(1)	0(0)	1(1)	141
SEDIMENTATION	2(2)	7(5)	5(4)	3(2)	5(4)	0(0)	1(1)	2(2)	2(2)	3(2)	128
CORROSION	9(7)	2(1)	3(2)	3(2)	6(4)	7(5)	3(2)	3(2)	1(1)	1(1)	134
FLOATING STRUCTURES	9(6)	2(1)	2(1)	3(2)	4(3)	4(3)	1(1)	1(1)	0(0)	1(1)	139
UNDERSEA STRUCTURES	8(6)	7(5)	3(2)	4(3)	5(4)	2(1)	3(2)	3(2)	1(1)	0(0)	142
PIPELINES	6(5)	7(5)	7(5)	5(4)	2(2)	3(2)	2(2)	5(4)	1(1)	0(0)	131
DREDGING	7(6)	11(8)	11(8)	5(4)	4(3)	5(4)	2(1)	3(2)	2(1)	0(0)	134

TABLE II-A (continued)

MASTER'S DEGREE PROGRAM - PRIORITIES IN APPLICATIONS

SUBJECT MATTER	1	2	3	4	5	6	7	8	9	10	11
					PRIORITY						
SALVAGE	1(1)*	0(0)	1(1)	0(0)	2(2)	3(3)	4(4)	1(1)	6(6)	2(2)	5(5)
TOOL DEVELOPMENT	0(0)	1(1)	4(4)	3(3)	2(2)	1(2)	6(5)	5(5)	3(3)	4(4)	5(5)
MINERAL RECOVERY	2(1)	1(1)	3(3)	2(2)	3(3)	0(0)	6(5)	4(3)	2(2)	4(3)	7(6)
MEASUREMENTS	9(7)	9(7)	3(2)	6(5)	11(8)	10(8)	9(7)	11(8)	7(5)	11(8)	3(2)
COMMUNICATIONS	1(1)	5(5)	3(3)	3(3)	2(2)	4(4)	3(3)	6(5)	5(4)	9(8)	7(6)
TRANSPORTATION	1(1)	0(0)	2(2)	0(0)	3(2)	14(10)	6(5)	4(3)	11(9)	2(2)	4(3)
OFFSHORE HARBORS	0(0)	4(3)	0(0)	2(2)	4(3)	4(3)	7(6)	4(3)	4(3)	6(5)	7(6)
MARICULTURE	0(0)	0(0)	1(1)	0(0)	0(0)	2(2)	1(1)	2(2)	1(1)	2(2)	2(2)
DEVELOPMENT OF COASTAL ZONE	4(3)	1(1)	3(2)	2(2)	5(4)	4(3)	6(5)	5(4)	6(5)	8(7)	7(6)
HARBOR ENG ENGINEERING	2(2)	5(4)	4(3)	4(3)	4(3)	4(3)	7(6)	9(7)	7(6)	7(6)	9(7)
ECOLOGICAL EFFECTS	4(3)	2(2)	3(2)	3(2)	7(5)	6(5)	10(8)	9(7)	7(5)	13(11)	7(5)

* Numbers in parentheses represent percentages

TABLE II-- B

MASTER'S DEGREE PROGRAM - PRIORITIES IN APPLICATIONS

SUBJECT MATTER	PRIORITY 12	13	14	15	16	17	18	19	20	21	22	TOTAL
SALVAGE	11(10)	4(4)	7(6)	6(6)	5(5)	8(8)	7(6)	19(17)	4(4)	5(5)	4(4)	105
TOOL DEVELOPMENT	8(7)	5(5)	3(3)	3(3)	9(7)	7(6)	5(5)	7(6)	11(9)	8(7)	10(8)	110
MINERAL RECOVERY	7(6)	9(8)	6(5)	12(10)	4(3)	9(8)	9(8)	7(6)	11(19)	8(7)	1(1)	117
MEASUREMENTS	5(4)	6(5)	5(4)	5(4)	6(5)	4(3)	4(3)	2(2)	3(2)	1(1)	0(0)	130
COMMUNICATIONS	4(4)	7(6)	5(4)	8(7)	7(6)	8(7)	7(6)	7(6)	2(2)	5(4)	5(4)	113
TRANSPORTATION	4(3)	4(3)	11(9)	8(6)	5(4)	7(6)	12(10)	4(3)	8(6)	11(9)	5(4)	126
OFFSHORE HARBORS	9(8)	10(9)	11(9)	9(8)	6(5)	7(6)	4(3)	7(6)	6(5)	4(3)	2(2)	116
MARICULTURE	2(2)	2(2)	3(3)	3(3)	7(7)	5(5)	2(2)	11(11)	8(8)	18(17)	30(29)	102
DEVELOPMENT OF COASTAL ZONE	3(2)	3(2)	4(3)	7(6)	14(12)	6(5)	10(9)	8(7)	5(4)	7(6)	3(2)	121
HARBOR ENGINEERING	8(6)	9(7)	6(5)	6(5)	5(2)	11(9)	5(4)	5(4)	5(4)	3(2)	3(2)	128
ECOLOGICAL EFFECTS	4(3)	7(5)	6(5)	7(5)	3(2)	6(5)	6(5)	3(2)	6(5)	5(4)	5(4)	129

TABLE II - B (continued)

MASTER'S DEGREE PROGRAM - PRIORITIES IN APPLICATIONS